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THE WORKS

OF

CHARLES KINGSLEY.

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VOLUME XIX.

SCIENTIFIC.

LECTURES AND ESSAYS.

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MM d. 20

London:
MACMILLAN AND CO.
1880.

SCIENTIFIC
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CHARLES DICKENS AND EVANS,
CRYSTAL PALACE PRESS.

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SCIENTIFIC
LECTURES AND ESSAYS.

TOWN GEOLOGY.

TOWN GEOLOGY.

PREFACE.

This little book, including the greater part of this Preface, has shaped itself out of lectures given to the young men of the city of Chester. But it does not deal, in its present form, with the geology of the neighbourhood of Chester only. I have tried so to recast it, that any townsman, at least in the manufacturing districts of England and Scotland, may learn from it to judge, roughly perhaps, but on the whole accurately, of the rocks and soils of his own neighbourhood. He will find, it is true, in these pages, little or nothing about those "Old Red Sandstones," so interesting to a Scotchman; and he will have to bear in mind, if he belong to the coal districts of Scotland, that the "stones in the wall" there belong to much older rocks than those "New Red Sandstones" of which this book treats; and that the coal measures of Scotland, with the volcanic rocks which have disturbed them, are often very different in appearance to the English coal measures. But he will soon learn to distinguish

the relative age of rocks by the fossils found in them, which he can now, happily, study in many local museums; and he may be certain, for the rest, that all rocks and soils whatsoever which he may meet have been laid down by the agents, and according to the laws, which I have tried to set forth in this book; and these only require, for the learning of them, the exercise of his own observation and common sense. I have not tried to make this a handbook of geological facts. Such a guide (and none better) the young man will find in Sir Charles Lyell's "Student's Elements of Geology." I have tried rather to teach the method of geology, than its facts; to furnish the student with a key to all geology, rough indeed and rudimentary, but sure and sound enough, I trust, to help him to unlock most geological problems which he may meet, in any quarter of the globe. But young men must remember always, that neither this book, nor all the books in the world, will make them geologists. No amount of book learning will make a man a scientific man; nothing but patient observation, and quiet and fair thought over what he has observed. He must go out for himself, see for himself, compare and judge for himself, in the field, the quarry, the cutting. He must study rocks, ores, fossils, in the nearest museum; and thus store his head, not with words, but with facts. He must verify—as far as he can—what he reads in books, by his own observation; and be slow to believe anything, even on the highest scientific authority, till he has either seen it, or something like enough to it to make it seem to him probable, or at least possible. So, and so only, will he become a scientific man, and a good geologist; and

acquire that habit of mind by which alone he can judge fairly and wisely of facts of any kind whatsoever.

I say—facts of any kind whatsoever. If any of my readers should be inclined to say to themselves: Geology may be a very pleasant study, but I have no special fancy for it. I had rather learn something of botany, astronomy, chemistry, or what not—I shall answer: By all means. Learn any branch of Natural Science you will. It matters little to me which you learn, provided you learn one at least. But bear in mind, and settle it in your hearts, that you will learn no branch of science soundly, so as to master it, and be able to make use of it, unless you acquire that habit and method of mind which I am trying to teach you in this book. I have tried to teach it you by geology, because geology is, perhaps, the simplest and the easiest of all physical sciences. It appeals more than any to mere common sense. It requires fewer difficult experiments, and expensive apparatus. It requires less previous knowledge of other sciences, whether pure or mixed; at least in its rudimentary stages. It is more free from long and puzzling Greek and Latin words. It is specially, the poor man's science. But if you do not like it, study something else. Only study that as you must study geology; proceeding from the known to the unknown by observation and experiment.

But here some of my readers may ask, as they have a perfect right to ask, why I wish young men to learn Natural Science at all? What good will the right understanding of geology, or of astronomy, or of chemistry, or of the plants or animals which they meet—what good, I say, will that do them?

In the first place, they need, I presume, occupation after their hours of work. If any of them answer: "We do not want occupation, we want amusement. Work is very dull, and we want something which will excite our fancy, imagination, sense of humour. We want poetry, fiction, even a good laugh or a game of play"—I shall most fully agree with them. There is often no better medicine for a hard-worked body and mind than a good laugh; and the man who can play most heartily when he has a chance of playing is generally the man who can work most heartily when he must work. But there is certainly nothing in the study of physical science to interfere with genial hilarity; though, indeed, some solemn persons have been wont to reprove the members of the British Association, and specially that Red Lion Club, where all the philosophers are expected to lash their tails and roar, of being somewhat too fond of mere and sheer fun, after the abstruse papers of the day are read and discussed. And as for harmless amusement, and still more for the free exercise of the fancy and the imagination, I know few studies to compare with Natural History; with the search for the most beautiful and curious productions of Nature amid her loveliest scenery, and in her freshest atmosphere. I have known again and again working men who in the midst of smoky cities have kept their bodies, their minds, and their hearts healthy and pure by going out into the country at odd hours, and making collections of fossils, plants, insects, birds, or some other objects of natural history; and I doubt not that such will be the case with some of my readers.

Another argument, and a very strong one, in favour of studying some branch of Natural Science just now is this—that without it you can hardly keep pace with the thought of the world around you.

Over and above the solid gain of a scientific habit of mind, of which I shall speak presently, the gain of mere facts, the increased knowledge of this planet on which we live, is very valuable just now; valuable certainly to all who do not wish their children and their younger brothers to know more about the universe than they do.

Natural Science is now occupying a more and more important place in education. Oxford, Cambridge, the London University, the public schools, one after another, are taking up the subject in earnest; so are the middle-class schools; so I trust will all primary schools throughout the country; and I hope that my children, at least, if not I myself, will see the day, when ignorance of the primary laws and facts of science will be looked on as a defect, only second to ignorance of the primary laws of religion and morality.

I speak strongly, but deliberately. It does seem to me strange, to use the mildest word, that people whose destiny it is to live, even for a few short years, on this planet which we call the earth, and who do not at all intend to live on it as hermits, shutting themselves up in cells, and looking on death as an escape and a deliverance, but intend to live as comfortably and wholesomely as they can, they and their children after them—it seems strange, I say, that such people should in general be so careless about the constitution of this same planet, and of the laws and facts on which depend,

not merely their comfort and their wealth, but their health and their very lives, and the health and the lives of their children and descendants.

I know some will say, at least to themselves: "What need for us to study science? There are plenty to do that already; and we shall be sure sooner or later to profit by their discoveries; and meanwhile it is not science which is needed to make mankind thrive, but simple common sense."

I should reply, that to expect to profit by other men's discoveries when you do not pay for them—to let others labour in the hope of entering into their labours, is not a very noble or generous state of mind—comparable somewhat, I should say, to that of the fatting ox, who willingly allows the farmer to house him, till for him, feed him, provided only he himself may lounge in his stall, and eat, and *not* be thankful. There is one difference in the two cases, but only one—that while the farmer can repay himself by eating the ox, the scientific man cannot repay himself by eating you; and so never gets paid, in most cases, at all.

But as for mankind thriving by common sense: they have not thriven by common sense, because they have not used their common sense according to that regulated method which is called science. In no age, in no country, as yet, have the majority of mankind been guided, I will not say by the love of God, and by the fear of God, but even by sense and reason. Not sense and reason, but nonsense and unreason, prejudice and fancy, greed and haste, have led them to such results as were to be expected—to superstitions, persecutions, wars, famines, pestilence, hereditary diseases, poverty, waste—waste incalculable, and now too often irre-

mediable—waste of life, of labour, of capital, of raw material, of soil, of manure, of every bounty which God has bestowed on man, till, as in the eastern Mediterranean, whole countries, some of the finest in the world, seem ruined for ever: and all because men will not learn nor obey those physical laws of the universe, which (whether we be conscious of them or not) are all around us, like walls of iron and of adamant—say rather, like some vast machine, ruthless though beneficent, among the wheels of which if we entangle ourselves in our rash ignorance, they will not stop to set us free, but crush us, as they have crushed whole nations and whole races ere now, to powder. Very terrible, though very calm, is outraged Nature.

> Though the mills of God grind slowly,
> Yet they grind exceeding small;
> Though He sit, and wait with patience,
> With exactness grinds He all.

It is, I believe, one of the most hopeful among the many hopeful signs of the times, that the civilised nations of Europe and America are awakening slowly but surely to this truth. The civilised world is learning, thank God, more and more of the importance of physical science; year by year, thank God, it is learning to live more and more according to those laws of physical science, which are, as the great Lord Bacon said of old, none other than "Vox Dei in rebus revelata"—the Word of God revealed in facts; and it is gaining by so doing, year by year, more and more of health and wealth; of peaceful and comfortable, even of graceful and elevating, means of life for fresh millions.

If you want to know what the study of physical

science has done for man, look, as a single instance, at the science of Sanatory Reform; the science which does not merely try to cure disease, and shut the stable-door after the horse is stolen, but tries to prevent disease; and, thank God, is succeeding beyond our highest expectations. Or look at the actual fresh amount of employment, of subsistence, which science has, during the last century, given to men; and judge for yourselves whether the study of it be not one worthy of those who wish to help themselves, and, in so doing, to help their fellow-men. Let me quote to you a passage from an essay urging the institution of schools of physical science for artisans, which says all which I wish to say and more:

"The discoveries of voltaic electricity, electro-magnetism, and magnetic electricity, by Volta, Œrsted, and Faraday, led to the invention of electric telegraphy by Wheatstone and others, and to the great manufactures of telegraph cables and telegraph wire, and of the materials required for them. The value of the cargo of the Great Eastern alone in the recent Bombay telegraph expedition was calculated at three millions of pounds sterling. It also led to the employment of thousands of operators to transmit the telegraphic messages, and to a great increase of our commerce in nearly all its branches by the more rapid means of communication. The discovery of Voltaic electricity further led to the invention of electro-plating, and to the employment of a large number of persons in that business. The numerous experimental researches on specific heat, latent heat, the tension of vapours, the properties of water, the mechanical effect of heat, etc., resulted in the development of steam-engines, and

railways, and the almost endless employments depending upon their construction and use. About a quarter of a million of persons are employed on railways alone in Great Britain. The various original investigations on the chemical effects of light led to the invention of photography, and have given employment to thousands of persons who practise that process, or manufacture and prepare the various material and articles required in it. The discovery of chlorine by Scheele led to the invention of the modern processes of bleaching, and to various improvements in the dyeing of the textile fabrics, and has given employment to a very large number of our Lancashire operatives. The discovery of chlorine has also contributed to the employment of thousands of printers, by enabling Esparto grass to be bleached and formed into paper for the use of our daily press. The numerous experimental investigations in relation to coal-gas have been the means of extending the use of that substance, and of increasing the employment of workmen and others connected with its manufacture. The discovery of the alkaline metals by Davy, of cyanide of potassium, of nickel, phosphorus, the common acids, and a multitude of other substances, has led to the employment of a whole army of workmen in the conversion of those substances into articles of utility. The foregoing examples might be greatly enlarged upon, and a great many others might be selected from the sciences of physics and chemistry: but those mentioned will suffice. There is not a force of Nature, nor scarcely a material substance that we employ, which has not been the subject of several, and in some cases of numerous, original experimental researches, many of which have resulted, in a greater or less degree,

in increasing the employment for workmen and others." *

"All this may be very true. But of what practical use will physical science be to me?"

Let me ask in return: Are none of you going to emigrate? If you have courage and wisdom, emigrate you will, some of you, instead of stopping here to scramble over each other's backs for the scraps, like black-beetles in a kitchen. And if you emigrate, you will soon find out, if you have eyes and common sense, that the vegetable wealth of the world is no more exhausted than its mineral wealth. Exhausted? Not half of it—I believe not a tenth of it—is yet known. Could I show you the wealth which I have seen in a single Tropic island, not sixty miles square—precious timbers, gums, fruits, what not, enough to give employment and wealth to thousands and tens of thousands, wasting for want of being known and worked—then you would see what a man who emigrates may do, by a little sound knowledge of botany alone.

And if not. Suppose that any one of you, learning a little sound Natural History, should abide here in Britain to your life's end, and observe nothing but the hedgerow plants, he would find that there is much more to be seen in those mere hedgerow plants than he fancies now. The microscope will reveal to him in the tissues of any wood, of any seed, wonders which will first amuse him, then puzzle him, and at last (I hope) awe him, as he perceives that smallness of size interferes in no way with perfection of development, and that "Nature," as has been well said, "is greatest in that which is least." And more. Suppose that he went further

* See "Nature," No. XXV. (Macmillan & Co.)

still. Suppose that he extended his researches somewhat to those minuter vegetable forms, the mosses, fungi, lichens; suppose that he went a little further still, and tried what the microscope would show him in any stagnant pool, whether fresh water or salt, of Desmidiæ, Diatoms, and all those wondrous atomies which seem as yet to defy our classification into plants or animals. Suppose he learnt something of this, but nothing of aught else. Would he have gained no solid wisdom? He would be a stupider man than I have a right to believe any of my readers to be, if he had not gained thereby somewhat of the most valuable of treasures—namely, that inductive habit of mind, that power of judging fairly of facts, without which no good or lasting work will be done, whether in physical science, in social science, in politics, in philosophy, in philology, or in history.

But more: let me urge you to study Natural Science, on grounds which may be to you new and unexpected—on social, I had almost said on political, grounds.

We all know, and I trust we all love, the names of Liberty, Equality, and Brotherhood. We feel, I trust, that these words are too beautiful not to represent true and just ideas; and that therefore they will come true, and be fulfilled, somewhen, somewhere, somehow. It may be in a shape very different from that which you, or I, or any man expects; but still they will be fulfilled.

But if they are to come true, it is we, the individual men, who must help them to come true for the whole world, by practising them ourselves, when and where we can. And I tell you—that in becoming scientific men, in studying science and acquiring the scientific

habit of mind, you will find yourselves enjoying a freedom, an equality, a brotherhood, such as you will not find elsewhere just now.

Freedom: what do we want freedom for? For this, at least; that we may be each and all able to think what we choose; and to say what we choose also, provided we do not say it rudely or violently, so as to provoke a breach of the peace. That last was Mr. Buckle's definition of freedom of speech. That was the only limit to it which he would allow; and I think that that is Mr. John Stuart Mill's limit also. It is mine. And I think we have that kind of freedom in these islands as perfectly as any men are likely to have it on this earth.

But what I complain of is, that when men have got the freedom, three out of four of them will not use it. What?—someone will answer—Do you suppose that I will not say what I choose, and that I dare not speak my own mind to any man? Doubtless. But are you sure first, that you think what you choose, or only what someone else chooses for you? Are you sure that you make up your own mind before you speak, or let someone else make it up for you? Your speech may be free enough, my good friend; and Heaven forbid that it should be anything else: but are your thoughts free likewise? Are you sure that, though you may hate bigotry in others, you are not somewhat of a bigot yourself? That you do not look at only one side of a question, and that the one which pleases you? That you do not take up your opinions at second hand, from some book or some newspaper, which after all only reflects your own feelings, your own opinions? You should ask yourselves that question, seriously and often:

"Are my thoughts really free?" No one values more highly than I do the advantage of a free press. But you must remember always that a newspaper editor, however honest or able, is no more infallible than the Pope; that he may, just as you may, only see one side of a question, while any question is sure to have two sides, or perhaps three or four; and if you only see the side which suits you, day after day, month after month, you must needs become bigoted to it. Your thoughts must needs run in one groove. They cannot (as Mr. Matthew Arnold would say) "play freely round" a question; and look it all over, boldly, patiently, rationally, charitably.

And I tell you that if you, or I, or any man, want to let our thoughts play freely round questions, and so escape from the tendency to become bigoted and narrow-minded which there is in every human being, then we must acquire something of that inductive habit of mind which the study of Natural Science gives. It is, after all, as Professor Huxley says, only common sense well regulated. But then it is well regulated; and how precious it is, if you can but get it. The art of seeing, the art of knowing what you see; the art of comparing, of perceiving true likenesses and true differences, and so of classifying and arranging what you see: the art of connecting facts together in your own mind in chains of cause and effect, and that accurately, patiently, calmly, without prejudice, vanity, or temper—this is what is wanted for true freedom of mind. But accuracy, patience, freedom from prejudice, carelessness for all except the truth, whatever the truth may be—are not these the virtues of a truly free spirit? Then, as I said just now, I know no study so able to give

that free habit of mind as the Study of Natural Science.

Equality, too: whatever equality may or may not be just, or possible; this at least, is just, and I hope possible; that every man, every child, of every rank, should have an equal chance of education; an equal chance of developing all that is in him by nature; an equal chance of acquiring a fair knowledge of those facts of the universe which specially concern him; and of having his reason trained to judge of them. I say, whatever equal rights men may or may not have, they have this right. Let every boy, every girl, have an equal and sound education. If I had my way, I would give the same education to the child of the collier and to the child of a peer. I would see that they were taught the same things, and by the same method. Let them all begin alike, say I. They will be handicapped heavily enough as they go on in life, without our handicapping them in their first race. Whatever stable they come out of, whatever promise they show, let them all train alike, and start fair, and let the best colt win.

Well: but there is a branch of education in which, even now, the poor man can compete fairly against the rich; and that is, Natural Science. In the first place, the rich, blind to their own interest, have neglected it hitherto in their schools; so that they have not the start of the poor man on that subject which they have on many. In the next place, Natural Science is a subject which a man cannot learn by paying for teachers. He must teach it himself, by patient observation, by patient common sense. And if the poor man is not the rich man's equal in those qualities, it must be his own fault, not his purse's. Many shops have I seen about the

world, in which fools could buy articles more or less helpful to them; but never saw I yet an observation-shop, nor a common-sense shop either. And if any man says, "We must buy books:" I answer, a poor man now can obtain better scientific books than a duke or a prince could sixty years ago, simply because then the books did not exist. When I was a boy I would have given much, or rather my father would have given much, if I could have got hold of such scientific books as are to be found now in any first-class elementary school. And if more expensive books are needed; if a microscope or apparatus is needed; can you not get them by the co-operative method, which has worked so well in other matters? Can you not form yourselves into a Natural Science club, for buying such things and lending them round among your members; and for discussion also, the reading of scientific papers of your own writing, the comparing of your observations, general mutual help and mutual instructions? Such societies are becoming numerous now, and gladly should I see one in every town. For in science, as in most matters, "As iron sharpeneth iron, so a man sharpeneth the countenance of his friend."

And Brotherhood: well, if you want that; if you want to mix with men, and men, too, eminently worth mixing with, on the simple ground that "a man's a man for a' that;" if you want to become the acquaintances, and—if you prove worthy—the friends, of men who will be glad to teach you all they know, and equally glad to learn from you anything you can teach them, asking no questions about you, save, first—Is he an honest student of Nature for her own sake? And next—Is he a man who will not quarrel, or other-

wise behave in an unbrotherly fashion to his fellow-students?—If you want a ground of brotherhood with men, not merely in these islands, but in America, on the Continent—in a word, all over the world—such as rank, wealth, fashion, or other artificial arrangements of the world cannot give and cannot take away; if you want to feel yourself as good as any man in theory, because you are as good as any man in practice, except those who are better than you in the same line, which is open to any and every man; if you wish to have the inspiring and ennobling feeling of being a brother in a great freemasonry which owns no difference of rank, of creed, or of nationality—the only freemasonry, the only International League which is likely to make mankind (as we all hope they will be some day) one—then become men of science. Join the freemasonry in which Hugh Miller, the poor Cromarty stonemason, in which Michael Faraday, the poor bookbinder's boy, became the companions and friends of the noblest and most learned on earth, looked up to by them not as equals merely but as teachers and guides, because philosophers and discoverers.

Do you wish to be great? Then be great with true greatness; which is,—knowing the facts of nature, and being able to use them. Do you wish to be strong? Then be strong with true strength; which is, knowing the facts of nature, and being able to use them. Do you wish to be wise? Then be wise with true wisdom; which is, knowing the facts of nature, and being able to use them. Do you wish to be free? Then be free with true freedom; which is again, knowing the facts of nature, and being able to use them.

I dare say some of my readers, especially the younger ones, will demur to that last speech of mine. Well, I hope they will not be angry with me for saying it. I, at least, shall certainly not be angry with them. For when I was young I was very much of what I suspect is their opinion. I used to think one could get perfect freedom, and social reform, and all that I wanted, by altering the arrangements of society and legislation; by constitutions, and Acts of Parliament; by putting society into some sort of freedom-mill, and grinding it all down, and regenerating it so. And that something can be done by improved arrangements, something can be done by Acts of Parliament, I hold still, as every rational man must hold.

But as I grew older, I began to see that if things were to be got right, the freedom-mill would do very little towards grinding them right, however well and amazingly it was made. I began to see that what sort of flour came out at one end of the mill, depended mainly on what sort of grain you had put in at the other; and I began to see that the problem was to get good grain, and then good flour would be turned out, even by a very clumsy old-fashioned sort of mill. And what do I mean by good grain? Good men, honest men, accurate men, righteous men, patient men, self-restraining men, fair men, modest men. Men who are aware of their own vast ignorance compared with the vast amount that there is to be learned in such a universe as this. Men who are accustomed to look at both sides of a question; who, instead of making up their minds in haste like bigots and fanatics, wait like wise men, for more facts, and more thought

about the facts. In one word, men who had acquired just the habit of mind which the study of Natural Science can give, and must give; for without it there is no use studying Natural Science; and the man who has not got that habit of mind, if he meddles with science, will merely become a quack and a charlatan, only fit to get his bread as a spirit-rapper, or an inventor of infallible pills.

And when I saw that, I said to myself—I will train myself, by Natural Science, to the truly rational, and therefore truly able and useful, habit of mind; and more, I will, for it is my duty as an Englishman, train every Englishman over whom I can get influence in the same scientific habit of mind, that I may, if possible, make him, too, a rational and an able man.

And, therefore, knowing that most of you, my readers—probably all of you, as you ought and must if you are Britons, think much of social and political questions—therefore, I say, I entreat you to cultivate the scientific spirit by which alone you can judge justly of those questions. I ask you to learn how to "conquer nature by obeying her," as the great Lord Bacon said two hundred and fifty years ago. For so only will you in your theories and your movements, draw "bills which nature will honour"—to use Mr. Carlyle's famous parable—because they are according to her unchanging laws, and not have them returned on your hands, as too many theorists' are, with "no effects" written across their backs.

Take my advice for yourselves, dear readers, and for your children after you; for, believe me, I am showing you the way to true and useful, and, therefore, to just and deserved power. I am showing you the

way to become members of what I trust will be—what I am certain ought to be—the aristocracy of the future.

I say it deliberately, as a student of society and of history. Power will pass more and more, if all goes healthily and well, into the hands of scientific men; into the hands of those who have made due use of that great heirloom which the philosophers of the seventeenth century left for the use of future generations, and specially of the Teutonic race.

For the rest, events seem but too likely to repeat themselves again and again all over the world, in the same hopeless circle. Aristocracies of mere birth decay and die, and give place to aristocracies of mere wealth; and they again to "aristocracies of genius," which are really aristocracies of the noisiest, of mere scribblers and spouters, such as France is writhing under at this moment. And when these last have blown off their steam, with mighty roar, but without moving the engine a single yard, then they are but too likely to give place to the worst of all aristocracies, the aristocracy of mere "order," which means organised brute force and military despotism. And, after that, what can come, save anarchy, and decay, and social death?

What else?—unless there be left in the nation, in the society, as the salt of the land, to keep it all from rotting, a sufficient number of wise men to form a true working aristocracy, an aristocracy of sound and rational science? If they be strong enough (and they are growing stronger day by day over the civilised world), on them will the future of that world mainly depend. They will rule, and they will act—cautiously, we may

hope, and modestly and charitably, because in learning true knowledge they will have learnt also their own ignorance, and the vastness, the complexity, the mystery of nature. But they will be able to rule, they will be able to act, because they have taken the trouble to learn the facts and the laws of nature. They will rule; and their rule, if they are true to themselves, will be one of health and wealth, and peace, of prudence and of justice. For they alone will be able to wield for the benefit of man the brute forces of nature; because they alone will have stooped to "conquer nature by obeying her."

So runs my dream. I ask my young readers to help towards making that dream a fact, by becoming (as many of them as feel the justice of my words) honest and earnest students of Natural Science.

But now: why should I, as a clergyman, interest myself specially in the spread of Natural Science? Am I not going out of my proper sphere to meddle with secular matters? Am I not, indeed, going into a sphere out of which I had better keep myself, and all over whom I may have influence? For is not science antagonistic to religion? and, if so, what has a clergyman to do, save to warn the young against it, instead of attracting them towards it?

First, as to meddling with secular matters. I grudge that epithet of "secular" to any matter whatsoever. But I do more; I deny it to anything which God has made, even to the tiniest of insects, the most insignificant atom of dust. To those who believe in God, and try to see all things in God, the most minute natural phenomenon cannot be secular. It must be divine; I say, deliberately, divine; and I can use no

less lofty word. The grain of dust is a thought of God; God's power made it; God's wisdom gave it whatsoever properties or qualities it may possess; God's providence has put it in the place where it is now, and has ordained that it should be in that place at that moment, by a train of causes and effects which reaches back to the very creation of the universe. The grain of dust can no more go from God's presence, or flee from God's Spirit, than you or I can. If it go up to the physical heaven, and float (as it actually often does) far above the clouds, in those higher strata of the atmosphere which the aeronaut has never visited, whither the Alpine snow-peaks do not rise, even there it will be obeying physical laws which we term hastily laws of Nature, but which are really the laws of God: and if it go down into the physical abyss; if it be buried fathoms, miles, below the surface, and become an atom of some rock still in the process of consolidation, has it escaped from God, even in the bowels of the earth? Is it not there still obeying physical laws, of pressure, heat, crystallisation, and so forth, which are laws of God—the will and mind of God concerning particles of matter? Only look at all created things in this light—look at them as what they are, the expressions of God's mind and will concerning this universe in which we live—"the Word of God," as Bacon says, "revealed in facts"—and then you will not fear physical science; for you will be sure that, the more you know of physical science, the more you will know of the works and of the will of God. At least, you will be in harmony with the teaching of the Psalmist: "The heavens," says he, "declare the glory of God; and the firmament showeth His handiwork. There is neither speech nor language

where their voices are not heard among them." So held the Psalmist concerning astronomy, the knowledge of the heavenly bodies; and what he says of sun and stars is true likewise of the flowers around our feet, of which the greatest Christian poet of modern times has said—

> To me the meanest flower that grows may give
> Thoughts that do lie too deep for tears.

So, again, you will be in harmony with the teaching of St. Paul, who told the Romans "that the invisible things of God are clearly seen from the creation of the world, being understood by the things that are made, even His eternal power and Godhead;" and who told the savages of Lycaonia that "God had not left Himself without witness, in that He did good and sent men rain from heaven, and fruitful seasons, filling men's hearts with food and gladness." Rain and fruitful seasons witnessed to all men of a Father in heaven. And he who wishes to know how truly St. Paul spoke, let him study the laws which produce and regulate rain and fruitful seasons, what we now call climatology, meteorology, geography of land and water. Let him read that truly noble Christian work, Maury's "Physical Geography of the Sea;" and see, if he be a truly rational man, how advanced science, instead of disproving, has only corroborated St. Paul's assertion, and how the ocean and the rain-cloud, like the sun and stars, declare the glory of God. And if anyone undervalues the sciences which teach us concerning stones and plants and animals, or thinks that nothing can be learnt from them concerning God—allow one who has been from childhood only a humble, though he trusts a diligent student of these sciences—allow him, I say, to ask in all reverence,

but in all frankness, who it was who said, "Consider the lilies of the field, how they grow." "Consider the birds of the air—and how your Heavenly Father feedeth them."

Consider them. If He has bid you do so, can you do so too much?

I know, of course, the special application which our Lord made of these words. But I know, too, from experience, that the more you study nature, in all her forms the more you will find that the special application itself is deeper, wider, more literally true, more wonderful, more tender, and if I dare use such a word, more poetic, than the unscientific man can guess.

But let me ask you further—do you think that our Lord in that instance, and in those many instances in which He drew his parables and lessons from natural objects, was leading men's minds on to dangerous ground, and pointing out to them a subject of contemplation in the laws and processes of the natural world, and their analogy with those of the spiritual world, the kingdom of God—a subject of contemplation, I say, which it was not safe to contemplate too much?

I appeal to your common sense. If He who spoke these words were (as I believe) none other than the Creator of the universe, by whom all things were made, and without whom nothing was made that is made, do you suppose that He would have bid you to consider His universe, had it been dangorous for you to do so?

Do you suppose, moreover, that the universe, which He, the Truth, the Light, the Love, has made, can be otherwise than infinitely worthy to be con-

sidered? or that the careful, accurate, and patient consideration of it, even to its minutest details, can be otherwise than useful to man, and can bear witness of aught, save the mind and character of Him who made it? And if so, can it be a work unfit for, unworthy of, a clergyman—whose duty is to preach Him to all, and in all ways,—to call on men to consider that physical world which, like the spiritual world, consists, holds together, by Him, and lives and moves and has its being in Him?

And here I must pause to answer an objection which I have heard in my youth from many pious and virtuous people—better people in God's sight, than I, I fear, can pretend to be.

They used to say, "This would be all very true if there were not a curse upon the earth." And then they seemed to deduce, from the fact of that curse, a vague notion (for it was little more) that this world was the devil's world, and that therefore physical facts could not be trusted, because they were disordered, and deceptive, and what not.

Now, in justice to the Bible, and in justice to the Church of England, I am bound to say that such a statement, or anything like it, is contrary to the doctrines of both. It is contrary to Scripture. According to it, the earth is not cursed. For it is said in Gen. viii. 21, "And the Lord said, I will not again curse the ground any more for man's sake. While the earth remaineth, seed-time and harvest, cold and heat, summer and winter, day and night shall not cease." According to Scripture, again, physical facts are not disordered. The Psalmist says, "They continue this day according to their ordinance;

for all things serve Thee." And again, "Thou hast made them fast for ever and ever. Thou hast given them a law which cannot be broken."

So does the Bible (not to quote over again the passages which I have already given you from St. Paul, and One greater than St. Paul) declare the permanence of natural laws, and the trustworthiness of natural phenomena as obedient to God. And so does the Church of England. For she has incorporated into her services that magnificent hymn, which our forefathers called the Song of the Three Children; which is, as it were, the very flower and crown of the Old Testament; the summing up of all that is true and eternal in the old Jewish faith; as true for us as for them: as true millions of years hence as it is now —which cries to all heaven and earth, from the skies above our heads to the green herb beneath our feet, "O all ye works of the Lord, bless ye the Lord; praise Him and magnify Him for ever." On that one hymn I take my stand. That is my charter as a student of Natural Science. As long as that is sung in an English church, I have a right to investigate Nature boldly without stint or stay, and to call on all who have the will, to investigate her boldly likewise, and with Socrates of old, to follow the Logos whithersoever it leads.

The Logos. I must pause on that word. It meant at first, no doubt, simply speech, argument, reason. In the mind of Socrates it had a deeper meaning, at which he only dimly guessed; which was seen more clearly by Philo and the Alexandrian Jews; which was revealed in all its fulness to the beloved Apostle St. John, till he gathered speech to tell men of a

Logos, a Word, who was in the beginning with God, and was God; by whom all things were made, and without Him was not anything made that was made; and how in Him was Life, and the Life was the light of men; and that He was none other than Jesus Christ our Lord.

Yes, that is the truth. And to that truth no man can add, and from it no man can take away. And as long as we believe that—as long as we believe that in His light alone can we see light—as long as we believe that the light around us, whether physical or spiritual, is given by Him without whom nothing is made—so long we shall not fear to meet Light, so long we shall not fear to investigate Life; for we shall know, however strange or novel, beautiful or awful, the discoveries we make may be, we are only following the Word whithersoever He may lead us; and that He can never lead us amiss.

I.

THE SOIL OF THE FIELD.*

My dear readers, let me, before touching on the special subject of this paper, say a few words on that of the whole series.

It is geology: that is, the science which explains to us the *rind* of the earth; of what it is made; how it has been made. It tells us nothing of the mass of the earth. That is, properly speaking, an astronomical question. If I may be allowed to liken this earth to a fruit, then astronomy will tell us—when it knows—how the fruit grew, and what is inside the fruit. Geology can only tell us at most how its rind, its outer covering, grew, and of what it is composed; a very small part, doubtless, of all that is to be known about this planet.

But as it happens, the mere rind of this earth-fruit which has, countless ages since, dropped, as it were, from the Bosom of God, the Eternal Fount of Life—the mere rind of this earth-fruit, I say, is so beautiful and so complex, that it is well worth our awful and reverent study. It has been well said, indeed, that the history of it, which we call geology, would be a mag-

* These Lectures were delivered to the members of the Natural Science Class at Chester in 1871.

nificent epic poem, were there only any human interest in it; did it deal with creatures more like ourselves than stones, and bones, and the dead relics of plants and beasts. Whether there be no human interest in geology; whether man did not exist on the earth during ages which have seen enormous geological changes, is becoming more and more an open question.

But meanwhile all must agree that there is matter enough for interest—nay, room enough for the free use of the imagination, in a science which tells of the growth and decay of whole mountain-ranges, continents, oceans, whole tribes and worlds of plants and animals.

And yet it is not so much for the vastness and grandeur of those scenes of the distant past, to which the science of geology introduces us, that I value it as a study, and wish earnestly to awaken you to its beauty and importance. It is because it is the science from which you will learn most easily a sound scientific habit of thought. I say most easily; and for these reasons. The most important facts of geology do not require, to discover them, any knowledge of mathematics or of chemical analysis; they may be studied in every bank, every grot, every quarry, every railway-cutting, by anyone who has eyes and common sense, and who chooses to copy the late illustrious Hugh Miller, who made himself a great geologist out of a poor stonemason. Next, its most important theories are not, or need not be, wrapped up in obscure Latin and Greek terms. They may be expressed in the simplest English, because they are discovered by simple common sense. And thus geology is (or ought to be), in popular parlance, the people's science—the science by studying which, the man ignorant of Latin,

Greek, mathematics, scientific chemistry, can yet become—as far as his brain enables him—a truly scientific man.

But how shall we learn science by mere common sense?

First. Always try to explain the unknown by the known. If you meet something which you have not seen before, then think of the thing most like it which you have seen before; and try if that which you know explains the one will not explain the other also. Sometimes it will; sometimes it will not. But if it will, no one has a right to ask you to try any other explanation.

Suppose, for instance, that you found a dead bird on the top of a cathedral tower, and were asked how you thought it had got there. You would say, "Of course, it died up here." But if a friend said, "Not so; it dropped from a balloon, or from the clouds;" and told you the prettiest tale of how the bird came to so strange an end, you would answer, "No, no; I must reason from what I know. I know that birds haunt the cathedral tower; I know that birds die; and therefore, let your story be as pretty as it may, my common sense bids me take the simplest explanation, and say—it died here." In saying that, you would be talking scientifically. You would have made a fair and sufficient induction (as it is called) from the facts about birds' habits and birds' deaths which you know.

But suppose that when you took the bird up you found that it was neither a jackdaw, nor a sparrow, nor a swallow, as you expected, but a humming-bird. Then you would be adrift again. The fact of it being a humming-bird would be a new fact which you had

not taken into account, and for which your old explanation was not sufficient; and you would have to try a new induction—to use your common sense afresh—saying, "I have not to explain merely how a dead bird got here, but how a dead humming-bird."

And now, if your imaginative friend chimed in triumphantly with: "Do you not see that I was right after all? Do you not see that it fell from the clouds? that it was swept away hither, all the way from South America, by some south-westerly storm, and wearied out at last, dropped here to find rest, as in a sacred place?" what would you answer? "My friend, that is a beautiful imagination; but I must treat it only as such, as long as I can explain the mystery more simply by facts which I do know. I do not know that humming-birds can be blown across the Atlantic alive. I do know they are actually brought across the Atlantic dead; are stuck in ladies' hats. I know that ladies visit the cathedral; and odd as the accident is, I prefer to believe, till I get a better explanation, that the humming-bird has simply dropped out of a lady's hat." There, again, you would be speaking common sense; and using, too, sound inductive method; trying to explain what you do not know from what you do know already.

Now, I ask of you to employ the same common sense when you read and think of Geology.

It is very necessary to do so. For in past times men have tried to explain the making of the world around them, its oceans, rivers, mountains, and continents, by I know not what of fancied cataclysms and convulsions of nature; explaining the unknown by the still more unknown, till some of their geological

theories were no more rational, because no more founded on known facts, than that of the New Zealand Maories, who hold that some god, when fishing, fished up their islands out of the bottom of the ocean. But a sounder and wiser school of geologists now reigns; the father of whom, in England at least, is the venerable Sir Charles Lyell. He was almost the first of Englishmen who taught us to see—what common sense tells us—that the laws which we see at work around us now have been most probably at work since the creation of the world; and that whatever changes may seem to have taken place in past ages, and in ancient rocks, should be explained, if possible, by the changes which are taking place now in the most recent deposits—in the soil of the field.

And in the last forty years—since that great and sound idea has become rooted in the minds of students, and especially of English students, geology has thriven and developed, perhaps more than any other science; and has led men on to discoveries far more really astonishing and awful than all fancied convulsions and cataclysms.

I have planned this series of papers, therefore, on Sir Charles Lyell's method. I have begun by trying to teach a little about the part of the earth's crust which lies nearest us, which we see most often; namely, the soil; intending, if my readers do me the honour to read the papers which follow, to lead them downward, as it were, into the earth; deeper and deeper in each paper, to rocks and minerals which are probably less known to them than the soil in the fields. Thus you will find I shall lead you, or try to lead you on, throughout the series, from the

known to the unknown, and show you how to explain the latter by the former. Sir Charles Lyell has, I see, in the new edition of his "Student's Elements of Geology," begun his book with the uppermost, that is, newest, strata, or layers; and has gone regularly downwards in the course of the book to the lowest or earliest strata; and I shall follow his plan.

I must ask you meanwhile to remember one law or rule, which seems to me founded on common sense; namely, that the uppermost strata are really almost always the newest; that when two or more layers, whether of rock or earth—or indeed two stones in the street, or two sheets on a bed, or two books on a table—any two or more lifeless things, in fact, lie one on the other, then the lower one was most probably put there first, and the upper one laid down on the lower. Does that seem to you a truism? Do I seem almost impertinent in asking you to remember it? So much the better. I shall be saved unnecessary trouble hereafter.

But some one may say, and will have a right to say, "Stop—the lower thing may have been thrust under the upper one." Quite true: and therefore I said only that the lower one was most probably put there first. And I said "most probably," because it is most probable that in nature we should find things done by the method which costs least force, just as you do them. I will warrant that when you want to hide a thing, you lay something down on it ten times for once that you thrust it under something else. You may say, "What? When I want to hide a paper, say, under the sofa-cover, do I not thrust it under?"

No, you lift up the cover, and slip the paper in, and let the cover fall on it again. And so, even in that case, the paper has got into its place first.

Now why is this? Simply because in laying one thing on another you only move weight. In thrusting one thing under another, you have not only to move weight, but to overcome friction. That is why you do it, though you are hardly aware of it: simply because so you employ less force, and take less trouble.

And so do clays and sands and stones. They are laid down on each other, and not thrust under each other, because thus less force is expended in getting them into place.

There are exceptions. There are cases in which nature does try to thrust one rock under another. But to do that she requires a force so enormous, compared with what is employed in laying one rock on another, that (so to speak) she continually fails; and instead of producing a volcanic eruption, produces only an earthquake. Of that I may speak hereafter, and may tell you, in good time, how to distinguish rocks which have been thrust in from beneath, from rocks which have been laid down from above, as every rock between London and Birmingham or Exeter has been laid down. That I only assert now. But I do not wish you to take it on trust from me. I wish to prove it to you as I go on, or to do what is far better for you: to put you in the way of proving it for yourself, by using your common sense.

At the risk of seeming prolix, I must say a few more words on this matter. I have special reasons for it. Until I can get you to "let your thoughts play freely" round this question of the superposition of soils and

rocks, there will be no use in my going on with these papers.

Suppose then (to argue from the known to the unknown) that you were watching men cleaning out a pond. Atop, perhaps, they would come to a layer of soft mud, and under that to a layer of sand. Would not common sense tell you that the sand was there first, and that the water had laid down the mud on the top of it? Then, perhaps, they might come to a layer of dead leaves. Would not common sense tell you that the leaves were there before the sand above them? Then, perhaps, to a layer of mud again. Would not common sense tell you that the mud was there before the leaves? And so on down to the bottom of the pond, where, lastly, I think common sense would tell you that the bottom of the pond was there already, before all the layers which were laid down on it. Is not that simple common sense?

Then apply that reasoning to the soils and rocks in any spot on earth. If you made a deep boring, and found, as you would in many parts of this kingdom, that the boring, after passing through the soil of the field, entered clays or loose sands, you would say the clays were there before the soil. If it then went down into sandstone, you would say—would you not?—that sandstone must have been here before the clay; and however thick—even thousands of feet—it might be, that would make no difference to your judgment. If next the boring came into quite different rocks; into a different sort of sandstone and shales, and among them beds of coal, would you not say—These coal-beds must have been here before the sandstones? And if you found in those coal-beds dead leaves and stems of

plants, would you not say—Those plants must have been laid down here before the layers above them, just as the dead leaves in the pond were?

If you then came to a layer of limestone, would you not say the same? And if you found that limestone full of shells and corals, dead, but many of them quite perfect, some of the corals plainly in the very place in which they grew, would you not say—These creatures must have lived down here before the coal was laid on top of them? And if, lastly, below the limestone you came to a bottom rock quite different again, would you not say—The bottom rock must have been here before the rocks on the top of it?

And if that bottom rock rose up a few miles off, two thousand feet, or any other height, into hills, what would you say then? Would you say: "Oh, but the rock is not bottom rock; is not under the limestone here, but higher than it. So perhaps in this part it has made a shift, and the highlands are younger than the lowlands; for see, they rise so much higher?" Would not that be as wise as to say that the bottom of the pond was not there before the pond mud, because the banks round the pond rose higher than the mud?

Now for the soil of the field.

If we can understand a little about it, what it is made of, and how it got there, we shall perhaps be on the right road toward understanding what all England —and, indeed, the crust of this whole planet—is made of; and how its rocks and soils got there.

But we shall best understand how the soil in the field was made, by reasoning, as I have said, from the known to the unknown. What do I mean? This.

On the uplands are fields in which the soil is already made. You do not know how? Then look for a field in which the soil is still being made. There are plenty in every lowland. Learn how it is being made there; apply the knowledge which you learn from them to the upland fields which are already made.

If there is, as there usually is, a river-meadow, or still better, an æstuary, near your town, you have every advantage for seeing soil made. Thousands of square feet of fresh-made soil spread between your town and the sea; thousands more are in process of being made.

You will see now why I have begun with the soil in the field; because it is the uppermost, and therefore latest, of all the layers; and also for this reason, that, if Sir Charles Lyell's theory be true—as it is—then the soils and rocks below the soil of the field may have been made in the very same way in which the soil of the field is made. If so, it is well worth our while to examine it.

You all know from whence the soil comes which has filled up, in the course of ages, the great æstuaries below London, Stirling, Chester, or Cambridge.

It is river mud and sand. The river, helped by tributary brooks right and left, has brought down from the inland that enormous mass. You know that. You know that every flood and freshet brings a fresh load, either of fine mud or of fine sand, or possibly some of it peaty matter out of distant hills. Here is one indisputable fact from which to start. Let us look for another.

How does the mud get into the river? The rain carries it thither.

If you wish to learn the first elements of geology by direct experiment, do this: The next rainy day—the harder it rains the better—instead of sitting at home over the fire, and reading a book about geology, put on a macintosh and thick boots, and get away, I care not whither, provided you can find there running water. If you have not time to get away to a hilly country, then go to the nearest bit of turnpike road, or the nearest sloping field, and see in little how whole continents are made, and unmade again. Watch the rain raking and sifting with its million delicate fingers, separating the finer particles from the coarser, dropping the latter as soon as it can, and carrying the former downward with it toward the sea. Follow the nearest roadside drain where it runs into a pond, and see how it drops the pebbles the moment it enters the pond, and then the sand in a fan-shaped heap at the nearest end; but carries the fine mud on, and holds it suspended, to be gradually deposited at the bottom in the still water; and say to yourself: Perhaps the sands which cover so many inland tracts were dropped by water, very near the shore of a lake or sea, and by rapid currents. Perhaps, again, the brick clays, which are often mingled with these sands, were dropped, like the mud in the pond, in deeper water farther from the shore, and certainly in still water. But more. Suppose once more, then, that looking and watching a pond being cleared out, under the lowest layer of mud, you found—as you would find in any of those magnificent reservoirs so common in the Lancashire hills—a layer of vegetable soil, with grass and brushwood rooted in it. What would you say but: The pond has not been always

full. It has at some time or other been dry enough to let a whole copse grow up inside it?

And if you found—as you will actually find along some English shores—under the sand hills, perhaps a bed of earth with shells and bones; under that a bed of peat; under that one of blue silt; under that a buried forest, with the trees upright and rooted; under that another layer of blue silt full of roots and vegetable fibre; perhaps under that again another old land surface with trees again growing in it; and under all the main bottom clay of the district—what would common sense tell you? I leave you to discover for yourselves. It certainly would not tell you that those trees were thrust in there by a violent convulsion, or that all those layers were deposited there in a few days, or even a few years; and you might safely indulge in speculations about the antiquity of the æstuary, and the changes which it has undergone, with which I will not frighten you at present.

It will be fair reasoning to argue thus. You may not be always right in your conclusion, but still you will be trying fairly to explain the unknown by the known.

But have Rain and Rivers alone made the soil?

How very much they have done toward making it you will be able to judge for yourselves, if you will read the sixth chapter of Sir Charles Lyell's new "Elements of Geology," or the first hundred pages of that admirable book, De la Bêche's "Geological Observer;" and last, but not least, a very clever little book called "Rain and Rivers," by Colonel George Greenwood.

But though rain, like rivers, is a carrier of soil, it

is more. It is a maker of soil, likewise; and by it mainly the soil of an upland field is made, whether it be carried down to the sea or not.

If you will look into any quarry you will see that however compact the rock may be a few feet below the surface, it becomes, in almost every case, rotten and broken up as it nears the upper soil, till you often cannot tell where the rock ends and the soil begins.

Now this change has been produced by rain. First, mechanically, by rain in the shape of ice. The winter rain gets into the ground, and does by the rock what it has done by the stones of many an old building. It sinks into the porous stone, freezes there, expands in freezing, and splits and peels the stone with a force which is slowly but surely crumbling the whole of Northern Europe and America to powder.

Do you doubt me? I say nothing but what you can judge of yourselves. The next time you go up any mountain, look at the loose broken stones with which the top is coated, just underneath the turf. What has broken them up but frost? Look again, as stronger proof, at the talus of broken stones—screes, as they call them in Scotland; rattles, as we call them in Devon—which lie along the base of many mountain cliffs. What has brought them down but frost? If you ask the country folk they will tell you whether I am right or not. If you go thither, not in the summer, but just after the winter's frost, you will see for yourselves, by the fresh frost-crop of newly-broken bits, that I am right. Possibly you may find me to be even more right than is desirable, by having a few angular stones, from the size of your head to that of your body, hurled at you by the frost-giants up above.

If you go to the Alps at certain seasons, and hear the thunder of the falling rocks, and see their long lines—moraines, as they are called—sliding slowly down upon the surface of the glacier, then you will be ready to believe the geologist who tells you that frost, and probably frost alone, has hewn out such a peak as the Matterhorn from some vast tableland; and is hewing it down still, winter after winter, till some day, where the snow Alps now stand, there shall be rolling uplands of rich cultivable soil.

So much for the mechanical action of rain, in the shape of ice. Now a few words on its chemical action.

Rain water is seldom pure. It carries in it carbonic acid; and that acid, beating in shower after shower against the face of a cliff—especially if it be a limestone cliff—weathers the rock chemically; changing (in case of limestone) the insoluble carbonate of lime into a soluble bicarbonate, and carrying that away in water, which, however clear, is still hard. Hard water is usually water which has invisible lime in it; there are from ten to fifteen grains and more of lime in every gallon of limestone water. I leave you to calculate the enormous weight of lime which must be so carried down to the sea every year by a single limestone or chalk brook. You can calculate it, if you like, by ascertaining the weight of lime in each gallon, and the average quantity of water which comes down the stream in a day; and when your sum is done, you will be astonished to find it one not of many pounds, but probably of many tons, of solid lime, which you never suspected or missed from the hills around. Again, by the time the rain has sunk through the soil, it is still less pure. It carries with it not only carbonic

acid, but acids produced by decaying vegetables—by the roots of the grasses and trees which grow above; and they dissolve the cement of the rock by chemical action, especially if the cement be lime or iron. You may see this for yourselves, again and again. You may see how the root of a tree, penetrating the earth, discolours the soil with which it is in contact. You may see how the whole rock, just below the soil, has often changed in colour from the compact rock below, if the soil be covered with a dense layer of peat or growing vegetables.

But there is another force at work, and quite as powerful as rain and rivers, making the soil of alluvial flats. Perhaps it has helped, likewise, to make the soil of all the lowlands in these isles—and that is, the waves of the sea.

If you ever go to Parkgate, in Cheshire, try if you cannot learn there a little geology.

Walk beyond the town. You find the shore protected for a long way by a sea-wall, lest it should be eaten away by the waves. What the force of those waves can be, even on that sheltered coast, you may judge—at least you could have judged this time last year—by the masses of masonry torn from their iron clampings during the gale of three winters since. Look steadily at those rolled blocks, those twisted stanchions, if they are there still; and then ask yourselves—it will be fair reasoning from the known to the unknown—What effect must such wave-power as that have had beating and breaking for thousands of years along the western coasts of England, Scotland, Ireland? It must have eaten up thousands of acres—whole shires, may be, ere now. Its teeth are strong enough,

and it knows neither rest nor pity, the cruel hungry sea. Give it but time enough, and what would it not eat up? It would eat up, in the course of ages, all the dry land of this planet, were it not baffled by another counteracting force, of which I shall speak hereafter.

As you go on beyond the sea-wall, you find what it is eating up. The whole low cliff is going visibly. But whither is it going? To form new soil in the æstuary. Now you will not wonder how old harbours so often become silted up. The sea has washed the land into them. But more, the sea-currents do not allow the sands of the æstuary to escape freely out to sea. They pile it up in shifting sand-banks about the mouth of the æstuary. The prevailing sea-winds, from whatever quarter, catch up the sand, and roll it up into sand-hills. Those sand-hills are again eaten down by the sea, and mixed with the mud of the tide-flats, and so is formed a mingled soil, partly of clayey mud, partly of sand; such a soil as stretches over the greater part of all our lowlands.

Now, why should not that soil, whether in England or in Scotland, have been made by the same means as that of every æstuary.

You find over great tracts of East Scotland, Lancashire, Norfolk, etc., pure loose sand just beneath the surface, which looks as if it was blown sand from a beach. Is it not reasonable to suppose that it is? You find rising out of many lowlands, crags which look exactly like old sea-cliffs eaten by the waves, from the base of which the waters have gone back. Why should not those crags be old sea-cliffs? Why should we not, following our rule of explaining the unknown by the

known, assume that such they are till someone gives us a sound proof that they are not; and say—These great plains of England and Scotland were probably once covered by a shallow sea, and their soils made as the soil of any tide-flat is being made now?

But you may say, and most reasonably, "The tide-flats are just at the sea-level. The whole of the lowland is many feet above the sea; it must therefore have been raised out of the sea, according to your theory: and what proofs have you of that?"

Well, that is a question both grand and deep, on which I shall not enter yet; but meanwhile, to satisfy you that I wish to play fair with you, I ask you to believe nothing but what you can prove for yourselves. Let me ask you this: suppose that you had proof positive that I had fallen into the river in the morning; would not your meeting me in the evening be also proof positive that somehow or other I had in the course of the day got out of the river? I think you will accept that logic as sound.

Now if I can give you proof positive, proof which you can see with your own eyes, and handle with your own hands, and alas! often feel but too keenly with your own feet, that the whole of the lowlands were once beneath the sea; then will it not be certain that, somehow or other, they must have been raised out of the sea again?

And that I propose to do in my next paper, when I speak of the pebbles in the street.

Meanwhile I wish you to face fairly the truly grand idea, which all I have said tends to prove true—that all the soil we see is made by the destruction of older soils, whether soft as clay, or hard as rock; that rain,

rivers, and seas are perpetually melting and grinding up old land, to compose new land out of it; and that it must have been doing so, as long as rain, rivers, and seas have existed. "But how did the first land of all get made?" I can only reply: A natural question: but we can only answer that, by working from the known to the unknown. While we are finding out how these later lands were made and unmade, we may stumble on some hints as to how the first primeval continents rose out of the bosom of the sea.

And thus I end this paper. I trust it has not been intolerably dull. But I wanted at starting to show my readers something of the right way of finding out truth on this and perhaps on all subjects; to make some simple appeals to your common sense; and to get you to accept some plain rules founded on common sense, which will be of infinite use to both you and me in my future papers.

I hope, meanwhile, that you will agree with me, that there is plenty of geological matter to be seen and thought over in the neighbourhood of any town.

Be sure, that wherever there is a river, even a drain; and a stone quarry, or even a roadside bank; much more where there is a sea, or a tidal æstuary, there is geology enough to be learnt, to explain the greater part of the making of all the continents on the globe.

II.

THE PEBBLES IN THE STREET.

If you, dear reader, dwell in any northern town, you will almost certainly see paving courts and alleys, and sometimes—to the discomfort of your feet—whole streets, or set up as bournestones at corners, or laid in heaps to be broken up for road-metal, certain round pebbles, usually dark brown or speckled gray, and exceedingly tough and hard. Some of them will be very large—boulders of several feet in diameter. If you move from town to town, from the north of Scotland as far down as Essex on the east, or as far down as Shrewsbury and Wolverhampton (at least) on the west, you will still find these pebbles, but fewer and smaller as you go south. It matters not what the rocks and soils of the country round may be. However much they may differ, these pebbles will be, on the whole, the same everywhere.

But if your town be south of the valley of the Thames, you will find, as far as I am aware, no such pebbles there. The gravels round you will be made up entirely of rolled chalk flints, and bits of beds

immediately above or below the chalk. The blocks of "Sarsden" sandstone—those of which Stonehenge is built—and the "plum-pudding stones" which are sometimes found with them, have no kindred with the northern pebbles. They belong to beds above the chalk.

Now if, seeing such pebbles about your town, you inquire, like a sensible person who wishes to understand something of the spot on which he lives, whence they come, you will be shown either a gravel-pit or a clay-pit. In the gravel the pebbles and boulders lie mixed with sand, as they do in the railway cutting just south of Shrewsbury; or in huge mounds of fine sweet earth, as they do in the gorge of the Tay about Dunkeld, and all the way up Strathmore, where they form long grassy mounds—*tomauns* as they call them in some parts of Scotland—*askers* as they call them in Ireland. These mounds, with their sweet fresh turf rising out of heather and bog, were tenanted—so Scottish children used to believe—by fairies. He that was lucky might hear inside them fairy music, and the jingling of the fairy horses' trappings. But woe to him if he fell asleep upon the mound, for he would be spirited away into fairyland for seven years, which would seem to him but one day. A strange fancy; yet not so strange as the actual truth as to what these mounds are, and how they came into their places.

Or again, you might find that your town's pebbles and boulders came out of a pit of clay, in which they were stuck, without any order or bedding, like plums and raisins in a pudding. This clay goes usually by the name of boulder-clay. You would see such near any town in Cheshire and Lancashire; or along Leith

shore, near Edinburgh; or, to give one more instance out of hundreds, along the coast at Scarborough. If you walk along the shore southward of that town, you will see, in the gullies of the cliff, great beds of sticky clay, stuffed full of bits of every rock between the Lake mountains and Scarborough, from rounded pebbles of most ancient rock down to great angular fragments of ironstone and coal. There, as elsewhere, the great majority of the pebbles have nothing to do with the rock on which the clay happens to lie, but have come, some of them, from places many miles away.

Now if we find spread over a low land pebbles composed of rocks which are only found in certain high lands, is it not an act of common sense to say—These pebbles have come from the highlands? And if the pebbles are rounded, while the rocks like them in the highlands always break off in angular shapes, is it not, again, an act of mere common sense to say—These pebbles were once angular, and have been rubbed round, either in getting hither or before they started hither?

Does all this seem to you mere truism, my dear reader? If so, I am sincerely glad to hear it. It was not so very long ago that such arguments would have been considered, not only no truisms, but not even common sense.

But to return, let us take, as an example, a sample of these boulder clay pebbles from the neighbourhood of Liverpool and Birkenhead, made by Mr. De Rance, the government geological surveyor:

Granite, greenstone, felspar porphyry, felstone, quartz rock (all igneous rocks, that is, either formed

by, or altered by volcanic heat, and almost all found in the Lake mountains), 37 per cent.

Silurian grits (the common stones of the Lake mountains deposited by water), 43 per cent.

Ironstone, 1 per cent.

Carboniferous limestone, 5 per cent.

Permian or Triassic sandstones, *i.e.* rocks immediately round Liverpool, 12 per cent.

Now, does not this sample show, as far as human common sense can be depended on, that the great majority of these stones come from the Lake mountains, sixty or seventy miles north of Liverpool? I think your common sense will tell you that these pebbles are not mere concretions; that is, formed out of the substance of the clay after it was deposited. The least knowledge of mineralogy would prove that. But, even if you are no mineralogist, common sense will tell you, that if they were all concreted out of the same clay, it is most likely that they would be all of the same kind, and not of a dozen or more different kinds. Common sense will tell you, also, that if they were all concreted out of the same clay, it is a most extraordinary coincidence, indeed one too strange to be believed, if any less strange explanation can be found —that they should have taken the composition of different rocks which are found all together in one group of mountains to the northward. You will surely say—If this be granite, it has most probably come from a granite mountain; if this be grit, from a grit-stone mountain, and so on with the whole list. Why are we to go out of our way to seek improbable explanations, when there is a probable one staring us in the face?

Next—and this is well worth your notice—if you will examine the pebbles carefully, especially the larger ones, you will find that they are not only more or less rounded, but often scratched; and often, too, in more than one direction, two or even three sets of scratches crossing each other; marked, as a cat marks an elder stem when she sharpens her claws upon it; and that these scratches have not been made by the quarrymen's tools, but are old marks which exist—as you may easily prove for yourself—while the stone is still lying in its bed of clay. Would it not be an act of mere common sense to say—These scratches have been made by the sharp points of other stones which have rubbed against the pebbles somewhere, and somewhen, with great force?

So far so good. The next question is—How did these stones get into the clay? If we can discover that, we may also discover how they were rounded and scratched. We must find a theory which will answer our question; and one which, as Professor Huxley would say, "will go on all-fours," that is, will explain all the facts of the case, and not only a few of them.

What, then, brought the stones?

We cannot, I think, answer that question, as some have tried to answer it, by saying that they were brought by Noah's flood. For it is clear, that very violent currents of water would be needed to carry boulders, some of them weighing many tons, for many miles. Now Scripture says nothing of any such violent currents; and we have no right to put currents, or any other imagined facts, into Scripture out of our own heads, and then argue from them as if not we, but the text of Scripture, had asserted their existence.

But still, they may have been rolled hither by water. That theory certainly would explain their being rounded; though not their being scratched. But it will not explain their being found in the clay.

Recollect what I said in my first paper: that water drops its pebbles and coarser particles first, while it carries the fine clayey mud onward in solution, and only drops it when the water becomes still. Now currents of such tremendous violence as to carry these boulder stones onward, would have carried the mud for many miles farther still; and we should find the boulders, not in clay, but lying loose together, probably on a hard rock bottom, scoured clean by the current. That is what we find in the beds of streams; that is just what we do not find in this case.

But the boulders may have been brought by a current, and then the water may have become still, and the clay settled quietly round them. What? Under them as well as over them? On that theory also we should find them only at the bottom of the clay. As it is, we find them scattered anywhere and everywhere through it, from top to bottom. So that theory will not do. Indeed, no theory will do which supposes them to have been brought by water alone.

Try yourself, dear reader, and make experiments, with running water, pebbles, and mud. If you try for seven years, I believe, you will never contrive to make your pebbles lie about in your mud, as they lie about in every pit in the boulder clay.

Well then, there we are at fault, it seems. We have no explanation drawn from known facts which will do—unless we are to suppose, which I don't think you will do, that stones, clay, and all were blown

hither along the surface of the ground, by primeval hurricanes, ten times worse than those of the West Indies, which certainly will roll a cannon a few yards, but cannot, surely, roll a boulder stone a hundred miles.

Now, suppose that there was a force, an agent, known—luckily for you, not to you—but known too well to sailors and travellers; a force which is at work over the vast sheets of land at both the north and south poles; at work, too, on every high mountain range in the world, and therefore a very common natural force; and suppose that this force would explain all the facts, namely—

How the stones got here;

How they were scratched and rounded;

How they were imbedded in clay;

because it is notoriously, and before men's eyes now, carrying great stones hundreds of miles, and scratching and rounding them also; carrying vast deposits of mud, too, and mixing up mud and stones just as we see them in the brick-pits,—Would not our common sense have a right to try that explanation?—to suspect that this force, which we do not see at work in Britain now, may have been at work here ages since? That would at least be reasoning from the known to the unknown. What state of things, then, do we find among the highest mountains; and over whole countries which, though not lofty, lie far enough north or south to be permanently covered with ice?

We find, first, an ice-cap or ice-sheet, fed by the winter's snows, stretching over the higher land, and crawling downward and outward by its own weight, along the valleys, as glaciers.

We find underneath the glaciers, first a *moraine profonde*, consisting of the boulders and gravel, and earth, which the glacier has ground off the hillsides, and is carrying down with it.

These stones, of course, grind, scratch, and polish each other; and in like wise grind, scratch, and polish the rock over which they pass, under the enormous weight of the superincumbent ice.

We find also, issuing from under each glacier a stream, carrying the finest mud, the result of the grinding of the boulders against each other and the glacier.

We find, moreover, on the surface of the glaciers, *moraines supérieures*—long lines of stones and dirt which had fallen from neighbouring cliffs, and are now travelling downward with the glaciers.

Their fate, if the glacier ends on land, is what was to be expected. The stones from above the glacier fall over the ice-cliff at its end, to mingle with those thrown out from underneath the glacier, and form huge banks of boulders, called terminal moraines, while the mud runs off, as all who have seen glaciers know, in a turbid torrent.

Their fate, again, is what was to be expected if the glacier ends, as it commonly does in Arctic regions, in the sea. The ice grows out to sea-ward for more than a mile sometimes, about one-eighth of it being above water, and seven-eighths below, so that an ice-cliff one hundred feet high may project into water eight hundred feet deep. At last, when it gets out of its depth, the buoyancy of the water breaks it off in ice-bergs, which float away, at the mercy of tides and currents, often grounding again in shallower water,

and ploughing the sea-bottom as they drag along it. These bergs carry stones and dirt, often in large quantities; so that, whenever a berg melts or capsizes, it strews its burden confusedly about the sea-floor.

Meanwhile the fine mud which is flowing out from under the ice goes out to sea likewise, colouring the water far out, and then subsiding as a soft tenacious ooze, in which the stones brought out by the ice are imbedded. And this ooze—so those who have examined it assert—cannot be distinguished from the brick-clay, or fossiliferous boulder-clay, so common in the North. A very illustrious Scandinavian explorer, visiting Edinburgh, declared, as soon as he saw the sections of boulder-clay exhibited near that city, that this was the very substance which he saw forming in the Spitzbergen ice-fiords.*

I have put these facts as simply and baldly as I can, in order that the reader may look steadily at them, without having his attention drawn off, or his fancy excited, by their real poetry and grandeur. Indeed, it would have been an impertinence to have done otherwise; for I have never seen a live glacier, by land or sea, though I have seen many a dead one. And the public has had the opportunity, lately, of reading so many delightful books about "peaks, passes, and glaciers," that I am bound to suppose that many of my readers know as much, or more, about them than I do.

* See a most charming paper on "The Physics of Arctic Ice," by Dr. Robert Brown of Campster, published in the *Quarterly Journal of the Geological Society*, June, 1870. This article is so remarkable, not only for its sound scientific matter, but for the vividness and poetic beauty of its descriptions, that I must express a hope that the learned author will some day enlarge it, and publish it in a separate form.

But let us go a step farther; and, bearing in our minds what live glaciers are like, let us imagine what a dead glacier would be like; a glacier, that is, which had melted, and left nothing but its skeleton of stones and dirt.

We should find the faces of the rock scored and polished, generally in lines pointing down the valleys, or at least outward from the centre of the highlands, and polished and scored most in their upland or weather sides. We should find blocks of rock left behind, and perched about on other rocks of a different kind. We should find in the valleys the old moraines left as vast deposits of boulder and shingle, which would be in time sawn through and sorted over by the rivers. And if the sea-bottom outside were upheaved, and became dry land, we should find on it the remains of the mud from under the glacier, stuck full of stones and boulders iceberg-dropped. This mud would be often very irregularly bedded; for it would have been disturbed by the ploughing of the icebergs, and mixed here and there with dirt which had fallen from them. Moreover, as the sea became shallower and the mud-beds got awash one after the other, they would be torn about, re-sifted, and re-shaped by currents and by tides, and mixed with shore-sand ground out of shingle-beach, thus making confusion worse confounded. A few shells, of an Arctic or northern type, would be found in it here and there. Some would have lived near those later beaches, some in deeper water in the ancient ooze, wherever the iceberg had left it in peace long enough for sea-animals to colonise and breed in it. But the general appear-

ance of the dried sea-bottom would be a dreary and lifeless waste of sands, gravels, loose boulders, and boulder-bearing clays; and wherever a boss of bare rock still stood up, it would be found ground down, and probably polished and scored by the ponderous icebergs which had lumbered over it in their passage out to sea.

In a word, it would look exactly as vast tracts of the English, Scotch, and Irish lowlands must have looked before returning vegetation coated their dreary sands and clays with a layer of brown vegetable soil.

Thus, and I believe thus only, can we explain the facts connected with these boulder pebbles. No agent known on earth can have stuck them in the clay, save ice, which is known to do so still elsewhere.

No known agent can have scratched them as they are scratched, save ice, which is known to do so still elsewhere.

No known agent—certainly not, in my opinion, the existing rivers—can have accumulated the vast beds of boulders which lie along the course of certain northern rivers; notably along the Dee about Aboyne —save ice bearing them slowly down from the distant summits of the Grampians.

No known agent, save ice, can have produced those rounded, and polished, and scored, and fluted *rochers moutonnés*—"sheep-backed rocks"—so common in the Lake district; so common, too, in Snowdon, especially between the two lakes of Llanberis; common in Kerry; to be seen anywhere, as far as I have ascertained, around the Scotch Highlands, where the turf is cleared away from an unweathered surface of the

rock, in the direction in which a glacier would have pressed against it had one been there. Where these polishings and scorings are found in narrow glens, it is, no doubt, an open question whether some of them may not be the work of water. But nothing but the action of ice can have produced what I have seen in land-locked and quiet fiords in Kerry—ice-fluting sin polished rocks below high-water mark, so large that I could lie down in one of them. Nothing but the action of ice could produce what may be seen in any of our mountains—whole sheets of rock ground down into rounded flats, irrespective of the lie of the beds, not in valleys, but on the brows and summits of mountains, often ending abruptly at the edge of some sudden cliff, where the true work of water, in the shape of rain and frost, is actually destroying the previous work of ice, and fulfilling the rule laid down (I think by Professor Geikie in his delightful book on Scotch scenery as influenced by its geology), that ice planes down into flats, while water saws out into crags and gullies; and that the rain and frost are even now restoring Scotch scenery to something of that ruggedness and picturesqueness which it must have lost when it lay, like Greenland, under the indiscriminating grinding of a heavy sheet of ice.

Lastly; no known agent, save ice, will explain those perched boulders, composed of ancient hard rocks, which may be seen in so many parts of these islands and of the Continent. No water power could have lifted those stones, and tossed them up high and dry on mountain ridges and promontories, upon rocks of a totally different kind. Some of my readers surely recollect Wordsworth's noble lines about these

mysterious wanderers, of which he had seen many a one about his native hills:

> As a huge stone is sometimes seen to lie
> Couched on the bald top of an eminence,
> Wonder to all who do the same espy
> By what means it could thither come, and whence;
> So that it seems a thing endued with sense:
> Like a sea-beast crawled forth, that on a shelf
> Of rock or sand reposeth, there to sun itself.

Yes; but the next time you see such a stone, believe that the wonder has been solved, and found to be, like most wonders in Nature, more wonderful than we guessed it to be. It is not a sea-beast which has crawled forth, but an ice-beast which has been left behind; lifted up thither by the ice, as surely as the famous Pierre-à-bot, forty feet in diameter, and hundreds of boulders more, almost as large as cottages, have been carried by ice from the distant Alps right across the lake of Neufchâtel, and stranded on the slopes of the Jura, nine hundred feet above the lake.*

Thus, I think, we have accounted for facts enough to make it probable that Britain was once covered partly by an ice-sheet, as Greenland is now, and partly, perhaps, by an icy sea. But, to make assurance more sure, let us look for new facts, and try whether our ice-dream will account for them also. Let us investigate our case as a good medical man does, by "verifying his first induction."

He says: At the first glance, I can see symptoms *a*, *b*, *c*. It is therefore probable that my patient has got complaint A. But if he has he ought to have symptom *d* also. If I find that, my guess will be yet

* See Lyell, "Antiquity of Man," p. 294 *et seq.*

more probable. He ought also to have symptom *e*, and so forth; and as I find successively each of these symptoms which are proper to A, my first guess will become more and more probable, till it reaches practical certainty.

Now let us do the same, and say—If this strange dream be true, and the lowlands of the North were once under an icy sea, ought we not to find sea-shells in their sands and clays? Not abundantly, of course. We can understand that the sea-animals would be too rapidly covered up in mud, and too much disturbed by icebergs and boulders, to be very abundant. But still, some should surely be found here and there.

Doubtless; and if my northern-town readers will search the boulder-clay pits near them, they will most probably find a few shells, if not in the clay itself, yet in sand-beds mixed with them, and probably underlying them. And this is a notable fact, that the more species of shells they find, the more they will find—if they work out their names from any good book of conchology—of a northern type; of shells which notoriously, at this day, inhabit the colder seas.

It is impossible for me here to enter at length on a subject on which a whole literature has been already written. Those who wish to study it may find all that they need know, and more, in Lyell's "Student's Elements of Geology," and in chapter xii. of his "Antiquity of Man." They will find that if the evidence of scientific conchologists be worth anything, the period can be pointed out in the strata, though not of course in time, at which these seas began to grow colder, and southern and Mediterranean shells to disappear, their places being taken by shells of a temperate,

and at last of an Arctic climate; which last have since retreated either toward their native North, or into cold water at great depths. From Essex across to Wales, from Wales to the æstuary of the Clyde, this fact has been verified again and again. And in the search for these shells, a fresh fact, and a most startling one, was discovered. They are to be found not only in the clay of the lowlands, but at considerable heights up the hills, showing that, at some time or other, these hills have been submerged beneath the sea.

Let me give one example, which any tourist into Wales may see for himself. Moel Tryfaen is a mountain over Carnarvon. Now perched on the side of that mountain, fourteen hundred feet above the present sea-level, is an ancient sea-beach, five-and-thirty feet thick, lying on great ice-scratched boulders, which again lie on the mountain slates. It was discovered by the late Mr. Trimmer, now, alas! lost to Geology. Out of that beach fifty-seven different species of shells have been taken; eleven of them are now exclusively Arctic, and not found in our seas; four of them are still common to the Arctic seas and to our own; and almost all the rest are northern shells.

Fourteen hundred feet above the present sea: and that, it must be understood, is not the greatest height at which such shells may be found hereafter. For, according to Professor Ramsay, drift of the same kind as that on Moel Tryfaen is found at a height of two thousand three hundred feet.

Now I ask my readers to use their common sense over this astounding fact—which, after all, is only one among hundreds; to let (as Mr. Matthew Arnold

would well say) their "thought play freely" about it; and consider for themselves what those shells must mean. I say not may, but must, unless we are to believe in a "Deus quidam deceptor," in a God who puts shells upon mountain-sides only to befool honest human beings, and gives men intellects which are worthless for even the simplest work. Those shells must mean that that mountain, and therefore the mountains round it, must have been once fourteen hundred feet at least lower than they are now. That the sea in which they were sunk was far colder than now. That icebergs brought and dropped boulders round their flanks. That upon those boulders a sea-beach formed, and that dead shells were beaten into it from a sea-bottom close by. That, and no less, Moel Tryfaen must mean.

But it must mean, also, a length of time which has been well called "appalling." A length of time sufficient to let the mountain sink into the sea. Then length of time enough to enable those Arctic shells to crawl down from the northward, settle, and propagate themselves generation after generation; then length of time enough to uplift their dead remains, and the beach, and the boulders, and all Snowdonia, fourteen hundred feet into the air. And if anyone should object that the last upheaval may have been effected suddenly by a few tremendous earthquakes, we must answer—We have no proof of it. Earthquakes upheave lands now only by slight and intermittent upward pulses; nay, some lands we know to rise without any earthquake pulses, but by simple, slow, upward swelling of a few feet in a century; and we have no reason, and therefore no right, to suppose that

Snowdonia was upheaved by any means or at any rate which we do not witness now; and therefore we are bound to allow, not only that there was a past "age of ice," but that that age was one of altogether enormous duration.

But meanwhile some of you, I presume, will be ready to cry—Stop! It may be our own weakness; but you are really going on too fast and too far for our small imaginations. Have you not played with us, as well as argued with us, till you have inveigled us step by step into a conclusion which we cannot and will not believe? That all this land should have been sunk beneath an icy sea? That Britain should have been as Greenland is now? We can't believe it, and we won't.

If you say so, like stout common-sense Britons, who have a wholesome dread of being taken in with fine words and wild speculations, I assure you I shall not laugh at you even in private. On the contrary, I shall say—what I am sure every scientific man will say—So much the better. That is the sort of audience which we want, if we are teaching natural science. We do not want haste, enthusiasm, *gobe-moucherie*, as the French call it, which is agape to snap up any new and vast fancy, just because it is new and vast. We want our readers to be slow, suspicious, conservative, ready to "gib," as we say of a horse, and refuse the collar up a steep place, saying—I must stop and think. I don't like the look of the path ahead of me. It seems an ugly place to get up. I don't know this road, and I shall not hurry over it. I must go back a few steps, and make sure. I must see whether it is the right road; whether there are not other roads, a

dozen of them perhaps, which would do as well and better than this.

This is the temper which finds out truth, slowly, but once and for all; and I shall be glad, not sorry, to see it in my readers.

And I am bound to say that it has been by that temper that this theory has been worked out, and the existence of this past age of ice, or glacial epoch, has been discovered, through many mistakes, many corrections, and many changes of opinion about details, for nearly forty years of hard work, by many men, in many lands.

As a very humble student of this subject, I may say that I have been looking these facts in the face earnestly enough for more than twenty years, and that I am about as certain that they can only be explained by ice, as I am that my having got home by rail can only be explained by steam.

But I think I know what startles you. It is the being asked to believe in such an enormous change in climate, and in the height of the land above the sea. Well—it is very astonishing, appalling—all but incredible, if we had not the facts to prove it. But of the facts there can be no doubt. There can be no doubt that the climate of this northern hemisphere has changed enormously more than once. There can be no doubt that the distribution of land and water, the shape and size of its continents and seas, have changed again and again. There can be no doubt that, for instance, long before the age of ice, the whole North of Europe was much warmer than it is now.

Take Greenland, for instance. Disco Island lies in Baffin's Bay, off the west coast of Greenland, in lati-

tude 70°, far within the Arctic circle. Now there certain strata of rock, older than the ice, have not been destroyed by the grinding of the ice-cap; and they are full of fossil plants. But of what kind of plants? Of the same families as now grow in the warmer parts of the United States. Even a tulip-tree has been found among them. Now how is this to be explained?

Either we must say that the climate of Greenland was then so much warmer than now, that it had summers probably as hot as those of New York; or we must say that these leaves and stems were floated thither from the United States. But if we say the latter, we must allow a change in the shape of the land which is enormous. For nothing now can float northward from the United States into Baffin's Bay. The polar current sets *out* of Baffin's Bay southward, bringing icebergs down, not leaves up, through Davis's Straits. And in any case we must allow that the hills of Disco Island were then the bottom of a sea: or how would the leaves have been deposited in them at all?

So much for the change of climate and land which can be proved to have gone on in Greenland. It has become colder. Why should it not some day become warmer again?

Now for England. It can be proved, as far as common sense can prove anything, that England was, before the age of ice, much warmer than it is now, and grew gradually cooler and cooler, just as, while the age of ice was dying out, it grew warmer again.

Now what proof is there of that?

This. Underneath London—as, I dare say, many of you know—there lies four or five hundred feet of

clay. But not ice-clay. Anything but that, as you will see. It belongs to a formation late (geologically speaking), but somewhat older than those Disco Island beds.

And what sort of fossils do we find in it?

In the first place, the shells, which are abundant, are tropical—Nautili, Cones, and such like. And more, fruits and seeds are found in it, especially at the Isle of Sheppey. And what are they? Fruits of Nipa palms, a form only found now at river-mouths in Eastern India and the Indian islands; Anona-seeds; gourd-seeds; Acacia fruits—all tropical again; and Proteaceous plants too—of an Australian type. Surely your common sense would hint to you, that this London clay must be mud laid down off the mouth of a tropical river. But your common sense would be all but certain of that, when you found, as you would find, the teeth and bones of crocodiles and turtles, who come to land, remember, to lay their eggs; the bones, too, of large mammals, allied to the tapir of India and South America, and the water-hog of the Cape. If all this does not mean that there was once a tropic climate and a tropic river running into some sea or other where London now stands, I must give up common sense and reason as deceitful and useless faculties; and believe nothing, not even the evidence of my own senses.

And now, have I, or have I not, fulfilled the promise which I made—rashly, I dare say some of you thought—in my first paper? Have I, or have I not, made you prove to yourself, by your own common sense, that the lowlands of Britain were underneath the sea in the days in which these pebbles and boulders

were laid down over your plains? Nay, have we not proved more? Have we not found that that old sea was an icy sea? Have we not wandered on, step by step, into a whole true fairyland of wonders? to a time when all England, Scotland, and Ireland were as Greenland is now? when mud streams have rushed down from under glaciers on to a cold sea-bottom, when "ice, mast high, came floating by, as green as emerald?" when Snowdon was sunk for at least fourteen hundred feet of its height? when (as I could prove to you, had I time) the peaks of the highest Cumberland and Scotch mountains alone stood out, as islets in a frozen sea?

We want to get an answer to one strange question, and we have found a group of questions stranger still, and got them answered too. But so it is always in science. We know not what we shall discover. But this, at least, we know, that it will be far more wonderful than we had dreamed. The scientific explorer is always like Saul of old, who set out simply to find his father's asses, and found them—and a kingdom besides.

I should have liked to have told you more about this bygone age of ice. I should have liked to say something to you on the curious question—which is still an open one—whether there were not two ages of ice; whether the climate here did not, after perhaps thousands of years of Arctic cold, soften somewhat for a while—a few thousand years, perhaps—and then harden again into a second age of ice, somewhat less severe, probably, than the first. I should have liked to have hinted at the probable causes of this change—indeed, of the age of ice altogether—whether it was

caused by a change in the distribution of land and water, or by change in the height and size of these islands, which made them large enough, and high enough, to carry a sheet of eternal snow inland; or whether, finally, the age of ice was caused by an actual change in the position of the whole planet with regard to its orbit round the sun—shifting at once the poles and the tropics; a deep question that latter, on which astronomers, whose business it is, are still at work, and on which, ere young folk are old, they will have discovered, I expect, some startling facts. On that last question, I, being no astronomer, cannot speak. But I should have liked to have said somewhat on matters on which I have knowledge enough, at least, to teach you how much there is to be learnt. I should have liked to tell the student of sea-animals—how the ice-age helps to explain, and is again explained by, the remarkable discoveries which Dr. Carpenter and Mr. Wyville Thompson have just made, in the deep-sea dredgings in the North Atlantic. I should have liked to tell the botanist somewhat of the pre-glacial flora—the plants which lived here before the ice, and lasted, some of them at least, through all those ages of fearful cold, and linger still on the summits of Snowdon, and the highest peaks of Cumberland and Scotland. I should have liked to have told the lovers of zoology about the animals which lived before the ice—of the mammoth, or woolly elephant; the woolly rhinoceros, the cave lion and bear, the reindeer, the musk oxen, the lemmings and the marmots which inhabited Britain till the ice drove them out southward, even into the South of France; and how as the ice retreated, and the climate became tolerable once more, some of them

—the mammoth and rhinoceros, the bison, the lion, and many another mighty beast reoccupied our lowlands, at a time when the hippopotamus, at least in summer, ranged freely from Africa and Spain across what was then dry land between France and England, and fed by the side of animals which have long since retreated to Norway and to Canada. I should have liked to tell the archæologist of the human beings—probably from their weapons and their habits—of the same race as the present Laplanders, who passed northward as the ice went back, following the wild reindeer herds from the South of France into our islands, which were no islands then, to be in their turn driven northward by stronger races from the east and south. But space presses, and I fear that I have written too much already.

At least, I have turned over for you a few grand and strange pages in the book of nature, and taught you, I hope, a key by which to decipher their hieroglyphics. At least, I have, I trust, taught you to look, as I do, with something of interest, even of awe, upon the pebbles in the street.

III.

THE STONES IN THE WALL.

THIS is a large subject. For in the different towns of these islands, the walls are built of stones of almost every age, from the earliest to the latest; and the town-geologist may find a quite different problem to solve in the nearest wall, on moving from one town to another twenty miles off. All I can do, therefore, is to take one set of towns, in the walls of which one sort of stones is commonly found, and talk of them; taking care, of course, to choose a stone which is widely distributed. And such, I think, we can find in the so-called New Red sandstone, which, with its attendant marls, covers a vast tract—and that a rich and busy one—of England. From Hartlepool and the mouth of the Tees, down through Yorkshire and Nottinghamshire; over the manufacturing districts of central England; down the valley of the Severn; past Bristol and the Somersetshire flats to Torquay in South Devon; up north-westward through Shropshire and Cheshire; past Liverpool and northward through Lancashire; reappearing again, north of the

Lake mountains, about Carlisle and the Scotch side of the Solway Frith, stretches the New Red sandstone plain, from under which everywhere the coal-bearing rocks rise as from a sea. It contains, in many places, excellent quarries of building-stone; the most famous of which, perhaps, are the well-known Runcorn quarries, near Liverpool, from which the old Romans brought the material for the walls and temples of ancient Chester, and from which the stone for the restoration of Chester Cathedral is being taken at this day. In some quarters, especially in the north-west of England, its soil is poor, because it is masked by that very boulder-clay of which I spoke in my last paper. But its rich red marls, wherever they come to the surface, are one of God's most precious gifts to this favoured land. On them, one finds oneself at once in a garden; amid the noblest of timber, wheat, roots, grass which is green through the driest summers, and, in the western counties, cider-orchards laden with red and golden fruit. I know, throughout northern Europe, no such charming scenery, for quiet beauty and solid wealth, as that of the New Red marls; and if I wished to show a foreigner what England was, I should take him along them, from Yorkshire to South Devon, and say—There. Is not that a country worth living for,—and worth dying for if need be?

Another reason which I have for dealing with the New Red sandstone is this—that (as I said just now) over great tracts of England, especially about the manufacturing districts, the town-geologist will find it covered immediately by the boulder clay.

The townsman, finding this, would have a fair right to suppose that the clay was laid down immediately, or

at least soon after, the sandstones or marls on which it lies; that as soon as the one had settled at the bottom of some old sea, the other settled on the top of it, in the same sea.

A fair and reasonable guess, which would in many cases, indeed in most, be quite true. But in this case it would be a mistake. The sandstone and marls are immensely older than the boulder-clay. They are, humanly speaking, some four or five worlds older.

What do I mean? This—that between the time when the one, and the time when the other, was made, the British Islands, and probably the whole continent of Europe, have changed four or five times; in shape; in height above the sea, or depth below it; in climate; in the kinds of plants and animals which have dwelt on them, or on their sea-bottoms. And surely it is not too strong a metaphor, to call such changes a change from an old world to a new one.

Mind. I do not say that these changes were sudden or violent. It is far more probable that they are only part and parcel of that vast but slow change which is going on everywhere over our whole globe. I think that will appear probable in the course of this paper. But that these changes have taken place, is my main thesis. The fact I assert; and I am bound to try and prove it. And in trying to do so, I shall no longer treat my readers, as I did in the first two papers, like children. I shall take for granted that they now understand something of the method by which geological problems are worked out; and can trust it, and me; and shall state boldly the conclusions of geologists, only giving proof where proof is specially needed.

Now you must understand that in England there

are two great divisions of these New Red sandstones, "Trias," as geologists call them. An upper, called in Germany Keuper, which consists, atop, of the rich red marl, below them, of sandstones, and of those vast deposits of rock-salt, which have been long worked, and worked to such good purpose, that a vast subsidence of land has just taken place near Nantwich in Cheshire; and serious fears are entertained lest the town itself may subside, to fill up the caverns below, from whence the salt has been quarried. Underneath these beds again are those which carry the building-stone of Runcorn. Now these beds altogether, in Cheshire, at least, are about 3,400 feet thick; and were not laid down in a year, or in a century either.

Below them lies a thousand feet of sandstones, known in Germany by the name of "Bunter," from its mottled and spotted appearance. What lies under them again, does not concern us just now.

I said that the geologists called these beds the Trias; that is, the triple group. But as yet we have heard of only two parts of it. Where is the third?

Not here, but in Germany. There, between the Keuper above and the Bunter below, lies a great series of limestone beds, which, from the abundance of fossils which they contain, go by the name of Muschelkalk. A long epoch must therefore have intervened between the laying down of the Bunter and of the Keuper. And we have a trace of that long epoch, even in England. The Keuper lies, certainly, immediately on the Bunter; but not always "conformably" on it. That is, the beds are not exactly parallel. The Bunter had been slightly tilted, and slightly waterworn, before the Keuper was laid on it.

It is reasonable, therefore, to suppose, that the Bunter in England was dry land, and therefore safe from fresh deposit, through ages during which it was deep enough beneath the sea in Germany, to have the Muschelkalk laid down on it. Here again, then, as everywhere, we have evidence of time—time, not only beyond all counting, but beyond all imagining.

And now, perhaps, the reader will ask—If I am to believe that all new land is made out of old land, and that all rocks and soils are derived from the wear and tear of still older rocks, off what land came this enormous heap of sands more than 5,000 feet thick in places, stretching across England and into Germany?

It is difficult to answer. The shape and distribution of land in those days were so different from what they are now, that the rocks which furnished a great deal of our sandstone may be now, for aught I know, a mile beneath the sea.

But over the land which still stands out of the sea near us there has been wear and tear enough to account for any quantity of sand deposit. As a single instance —It is a provable and proven fact—as you may see from Mr. Ramsay's survey of North Wales—that over a large tract to the south of Snowdon, between Port Madoc and Barmouth, there has been ground off and carried away a mass of solid rock 20,000 feet thick; thick enough, in fact, if it were there still, to make a range of mountains as high as the Andes. It is a provable and proven fact that vast tracts of the centre of poor old Ireland were once covered with coal-measures, which have been scraped off in likewise, deprived of inestimable mineral wealth. The destruction of rocks—"denudation" as it is called—in the

district round Malvern, is, I am told, provably enormous. Indeed, it is so over all Wales, North England, and West and North Scotland. So there is enough of rubbish to be accounted for to make our New Red sands. The round pebbles in it being, I believe, pieces of Old Red sandstone, may have come from the great Old Red sandstone region of South East Wales and Herefordshire. Some of the rubbish, too, may have come from what is now the Isle of Anglesey.

For you find in the beds, from the top to the bottom (at least in Cheshire), particles of mica. Now this mica could not have been formed in the sand. It is a definite crystalline mineral, whose composition is well known. It is only found in rocks which have been subjected to immense pressure, and probably to heat. The granites and mica-slates of Anglesey are full of it; and from Anglesey—as likely as from anywhere else—these thin scales of mica came. And that is about all that I can say on the matter. But it is certain that most of these sands were deposited in a very shallow water, and very near to land. Sand and pebbles, as I said in my first paper, could not be carried far out to sea; and some of the beds of the Bunter are full of rounded pebbles. Nay, it is certain that their surface was often out of water. Of that you may see very pretty proofs. You find these sands ripple-marked, as you do shore-sands now. You find cracks where the marl mud has dried in the sun: and, more, you find the little pits made by rain. Of that I have no doubt. I have seen specimens, in which you could not only see at a glance that the marks had been made by the large drops of a shower, but see also from what direction the shower had come. These delicate

markings must have been covered up immediately with a fresh layer of mud or sand. How long since? How long since that flag had seen the light of the sun, when it saw it once again, restored to the upper air by the pick of the quarryman? Who can answer that? Not I.

Fossils are very rare in these sands; it is not easy to say why. It may be that the red oxide of iron in them has destroyed them. Few or none are ever found in beds in which it abounds. It is curious, too, that the Keuper, which is all but barren of fossils in England, is full of them in Würtemberg, reptiles, fish, and remains of plants being common. But what will interest the reader are the footprints of a strange beast, found alike in England and in Germany—the Cheirotherium, as it was first named, from its hand-like feet; the Labyrinthodon, as it is now named, from the extraordinary structure of its teeth. There is little doubt now, among anatomists, that the bones and teeth of the so-called Labyrinthodon belong to the animal which made the footprints. If so, the creature must have been a right loathly monster. Some think him to have been akin to lizards; but the usual opinion is that he was a cousin of frogs and toads. Looking at his hands and other remains, one pictures him to oneself as a short, squat brute, as big as a fat hog, with a head very much the shape of a baboon, very large hands behind and small ones in front, waddling about on the tide flats of a sandy sea, and dragging after him, seemingly, a short tail, which has left its mark on the sand. What his colour was, whether he was smooth or warty, what he ate, and in general how he got his living, we know not. But

there must have been something there for him to eat; and I dare say that he was about as happy and about as intellectual as the toad is now. Remember always that there is nothing alive now exactly like him, or, indeed, like any animal found in these sandstones. The whole animal world of this planet has changed entirely more than once since the Labyrinthodon waddled over the Cheshire flats. A lizard, for instance, which has been found in the Keuper, had a skull like a bird's, and no teeth—a type which is now quite extinct. But there is a more remarkable animal of which I must say a few words, and one which to scientific men is most interesting and significant.

Both near Warwick, and near Elgin in Scotland, in Central India, and in South Africa, fossil remains are found of a family of lizards utterly unlike anything now living save one, and that one is crawling about, plentifully I believe—of all places in the world—in New Zealand. How it got there; how so strange a type of creature should have died out over the rest of the world, and yet have lasted on in that remote island for long ages, ever since the days of the New Red sandstone, is one of those questions—quite awful questions I consider them—with which I will not puzzle my readers. I only mention it to show them what serious questions the scientific man has to face, and to answer, if he can. Only the next time they go to the Zoological Gardens in London, let them go to the reptile-house, and ask the very clever and courteous attendant to show them the Sphenodons, or Hatterias, as he will probably call them—and then look, I hope with kindly interest, at the oldest Conservatives they ever saw, or are like to see; gentlemen of

most ancient pedigree, who have remained all but unchanged, while the whole surface of the globe has changed around them more than once or twice.

And now, of course, my readers will expect to hear something of the deposits of rock-salt, for which Cheshire and its red rocks are famous. I have never seen them, and can only say that the salt does not, it is said by geologists, lie in the sandstone, but at the bottom of the red marl which caps the sandstone. It was formed most probably by the gradual drying up of lagoons, such as are depositing salt, it is said now, both in the Gulf of Tadjara, on the Abyssinian frontier opposite Aden, and in the Runn of Cutch, near the Delta of the Indus. If this be so, then these New Red sandstones may be the remains of a whole Sahara —a sheet of sandy and all but lifeless deserts, reaching from the west of England into Germany, and rising slowly out of the sea; to sink, as we shall find, beneath the sea again.

And now, as to the vast period of time—the four or five worlds, as I called it—which elapsed between the laying down of the New Red sandstones and the laying down of the boulder-clays.

I think this fact—for fact it is—may be better proved by taking readers an imaginary railway journey to London from any spot in the manufacturing districts of central England—begging them, meanwhile, to keep their eyes open on the way.

And here I must say that I wish folks in general would keep their eyes a little more open when they travel by rail. When I see young people rolling along in a luxurious carriage, their eyes and their brains absorbed probably in a trashy shilling novel, and never

lifted up to look out of the window, unconscious of all that they are passing—of the reverend antiquities, the admirable agriculture, the rich and peaceful scenery, the like of which no country upon earth can show; unconscious, too, of how much they might learn of botany and zoology, by simply watching the flowers along the railway banks and the sections in the cuttings: then it grieves me to see what little use people make of the eyes and of the understanding which God has given them. They complain of a dull journey: but it is not the journey which is dull; it is they who are dull. Eyes have they, and see not; ears have they, and hear not; mere dolls in smart clothes, too many of them, like the idols of the heathen.

But my readers, I trust, are of a better mind. So the next time they find themselves running up southward to London—or the reverse way—let them keep their eyes open, and verify, with the help of a geological map, the sketch which is given in the following pages.

Of the "Black Countries"—the actual coal districts I shall speak hereafter. They are in England either shores or islands yet undestroyed, which stand out of the great sea of New Red sandstone, and often carry along their edges layers of far younger rocks, called now Permian, from the ancient kingdom of Permia, in Russia, where they cover a vast area. With them I will not confuse the reader just now, but will only ask him to keep his eye on the rolling plain of New Red sands and marls past, say, Birmingham and Warwick. After those places, these sands and marls dip to the south-east, and other rocks and soils appear above them, one after another, dipping likewise towards the south-east—that is, toward London.

First appear thin layers of a very hard blue limestone, full of shells, and parted by layers of blue mud. That rock runs in a broad belt across England, from Whitby in Yorkshire, to Lyme in Dorsetshire, and is known as Lias. Famous it is, as some readers may know, for holding the bones of extinct monsters—Ichthyosaurs and Plesiosaurs, such as the unlearned may behold in the lake at the Crystal Palace. On this rock lie the rich cheese pastures, and the best tracts of the famous "hunting shires" of England.

Lying on it, as we go south-eastward, appear alternate beds of sandy limestone, with vast depths of clay between them. These "oolites," or freestones, furnish the famous Bath stone, the Oxford stone, and the Barnack stone of Northamptonshire, of which some of the finest cathedrals are built—a stone only surpassed, I believe, by the Caen stone, which comes from beds of the same age in Normandy. These freestones and clays abound in fossils, but of kinds, be it remembered, which differ more and more from those of the lias beneath, as the beds are higher in the series, and therefore nearer. There, too, are found principally the bones of that extraordinary flying lizard, the Pterodactyle, which had wings formed out of its fore-legs, on somewhat the same plan as those of a bat, but with one exception. In the bat, as any one may see, four fingers of the hand are lengthened to carry the wing, while the first alone is left free, as a thumb: but in the Pterodactyle, the outer or "little" finger alone is lengthened, and the other four fingers left free—one of those strange instances in nature of the same effect being produced in widely different plants and animals, and yet by

slightly different means, on which a whole chapter of natural philosophy—say, rather, natural theology—will have to be written some day.

But now consider what this Lias, and the Oolites and clays upon it mean. They mean that the New Red sandstone, after it had been dry land, or all but dry land (as is proved by the footprints of animals and the deposits of salt), was sunk again beneath the sea. Each deposit of limestone signifies a long period of time, during which that sea was pure enough to allow reefs of coral to grow, and shells to propagate, at the bottom. Each great band of clay signifies a long period, during which fine mud was brought down from some wasting land in the neighbourhood. And that land was not far distant is proved by the bones of the Pterodactyle, of Crocodiles, and of Marsupials; by the fact that the shells are of shallow-water or shore species; by the presence, mixed with them, of fragments of wood, impressions of plants, and even wing-shells of beetles; and lastly, if further proof was needed, by the fact that in the "dirt-bed" of the Isle of Portland and the neighbouring shores, stumps of trees allied to the modern sago-palms are found as they grew in the soil, which, with them, has been covered up in layers of freshwater shale and limestone. A tropic forest has plainly sunk beneath a lagoon; and that lagoon, again, beneath the sea.

And how long did this period of slow sinking go on? Who can tell? The thickness of the Lias and Oolites together cannot be less than a thousand feet. Considering, then, the length of time required to lay down a thousand feet of strata, and considering the vast difference between the animals found in them, and the

few found in the New Red sandstone, we have a right to call them another world, and that one which must have lasted for ages.

After we pass Oxford, or the Vale of Aylesbury, we enter yet another world. We come to a bed of sand, under which the freestones and their adjoining clays dip to the south-east. This is called commonly the lower Greensand, though it is not green, but rich iron-red. Then succeeds a band of stiff blue clay, called the Gault, and then another bed of sand, the upper Greensand, which is more worthy of the name, for it does carry, in most places, a band of green or "glauconite" sand. But it and the upper layers of the lower Greensand also, are worth our attention; for we are all probably eating them from time to time in the form of bran.

It had been long remarked that certain parts of these beds carried admirable wheatland; it had been remarked, too, that the finest hop-lands—those of Farnham, for instance, and Tunbridge—lay upon them: but that the fertile band was very narrow; that, as in the Surrey Moors, vast sheets of the lower Greensand were not worth cultivation. What caused the striking difference?

My beloved friend and teacher, the late Dr. Henslow, when Professor of Botany at Cambridge, had brought to him by a farmer (so the story ran) a few fossils. He saw, being somewhat of a geologist and chemist, that they were not, as fossils usually are, carbonate of lime, but phosphate of lime—bone-earth. He said at once, as by an inspiration, "You have found a treasure—not a gold-mine, indeed, but a food-mine. This is bone-earth, which we are at our wits'

end to get for our grain and pulse; which we are importing, as expensive bones, all the way from Buenos Ayres. Only find enough of them, and you will increase immensely the food supply of England, and perhaps make her independent of foreign phosphates in case of war."

His advice was acted on; for the British farmer is by no means the stupid personage which townsfolk are too apt to fancy him. This bed of phosphates was found everywhere in the Greensand, underlying the Chalk. It may be traced from Dorsetshire through England to Cambridge, and thence, I believe, into Yorkshire. It may be traced again, I believe, all round the Weald of Kent and Sussex, from Hythe to Farnham —where it is peculiarly rich—and so to Eastbourne and Beachey Head; and it furnishes, in Cambridgeshire, the greater part of those so-called "coprolites," which are used perpetually now for manure, being ground up, and then treated with sulphuric acid, till they become a "soluble super-phosphate of lime."

So much for the useless "hobby," as some fancy it, of poking over old bones and stones, and learning a little of the composition of this earth on which God has placed us.

How to explain the presence of this vast mass of animal matter, in one or two thin bands right across England, I know not. That the fossils have been rolled on a sea-beach is plain to those who look at them. But what caused so vast a destruction of animal life along that beach, must remain one of the buried secrets of the past.

And now we are fast nearing another world, which is far younger than that coprolite bed, and has been formed under circumstances the most opposite to it.

We are nearing, by whatever rail we approach London, the escarpment of the chalk downs.

All readers, surely, know the white chalk, the special feature and the special pride of the south of England. All know its softly-rounded downs, its vast beech woods, its short and sweet turf, its snowy cliffs, which have given—so some say—to the whole island the name of Albion—the white land. But all do not, perhaps, know that till we get to the chalk no single plant or animal has been found which is exactly like any plant or animal now known to be living. The plants and animals grow, on the whole, more and more like our living forms as we rise in the series of beds. But only above the chalk (as far as we yet know) do we begin to find species identical with those living now.

This in itself would prove a vast lapse of time. We shall have a further proof of that vast lapse when we examine the chalk itself. It is composed—of this there is now no doubt—almost entirely of the shells of minute animalcules; and animalcules (I use an unscientific word for the sake of unscientific readers) like these, and in some cases identical with them, are now forming a similar deposit of mud, at vast depths, over the greater part of the Atlantic sea-floor. This fact has been put out of doubt by recent deep-sea dredgings. A whole literature has been written on it of late. Any reader who wishes to know it, need only ask the first geologist he meets; and if he has the wholesome instinct of wonder in him, fill his imagination with true wonders, more grand and strange than he is like to find in any fairy tale. All I have to do with the matter here is, to say that, arguing from the

known to the unknown, from the Atlantic deep-sea ooze which we do know about, to the chalk which we do not know about, the whole of the chalk must have been laid down at the bottom of a deep and still ocean, far out of the reach of winds, tides, and even currents, as a great part of the Atlantic sea-floor is at this day.

Prodigious! says the reader. And so it is. Prodigious to think that that shallow Greensand shore, strewed with dead animals, should sink to the bottom of an ocean, perhaps a mile, perhaps some four miles deep. Prodigious the time during which it must have lain as a still ocean-floor. For so minute are the living atomies which form the ooze, that an inch, I should say, is as much as we can allow for their yearly deposit; and the chalk is at least a thousand feet thick. It may have taken, therefore, twelve thousand years to form the chalk alone. A rough guess, of course, but one as likely to be two or three times too little as two or three times too big. Such, or somewhat such, is the fact. It had long been suspected, and more than suspected; and the late discoveries of Dr. Carpenter and Mr. Wyville Thompson have surely placed it beyond doubt.

Thus, surely, if we call the Oolitic beds one new world above the New Red sandstone, we must call the chalk a second new world in like wise.

I will not trouble the reader here with the reasons why geologists connect the chalk with the greensands below it, by regular gradations, in spite of the enormous downward leap, from sea-shore to deep ocean, which the beds seem (but only seem) to have taken. The change—like all changes in geology—was probably

gradual. Not by spasmodic leaps and starts, but slowly and stately, as befits a God of order, of patience, and of strength, have these great deeds been done.

But we have not yet done with new worlds or new prodigies on our way to London, as any Londoner may ascertain for himself, if he will run out a few miles by rail, and look in any cutting or pit, where the surface of the chalk, and the beds which lie on it, are exposed.

On the chalk lie—especially in the Blackheath and Woolwich district—sands and clays. And what do they tell us?

Of another new world, in which the chalk has been lifted up again, to form gradually, doubtless, and at different points in succession, the shore of a sea.

But what proof is there of this?

The surface of the chalk is not flat and smooth, as it must have been when at the bottom of the sea. It is eaten out into holes and furrows, plainly by the gnawing of the waves; and on it lie, in many places, large rolled flints out of chalk which has been destroyed, beds of shore-shingle, beds of oysters lying as they grew, fresh or brackish water-shells standing as they lived, bits of lignite (fossil wood half turned to coal), and (as in Katesgrove pits at Reading) leaves of trees. Proof enough, one would say, that the chalk had been raised till part of it at least became dry land, and carried vegetation.

And yet we have not done. There is another world to tell of yet.

For these beds (known as the Woolwich and Reading beds) dip under that vast bed of London clay, four hundred and more feet thick, which (as I

said in my last chapter) was certainly laid down by the estuary of some great tropic river, among palm-trees and Anonas, crocodiles and turtles.

Is the reader's power of belief exhausted?

If not: there are to be seen, capping almost every high land round London, the remains of a fifth world. Some of my readers may have been to Ascot races, or to Aldershot camp, and may recollect the table-land of the sandy moors, perfectly flat atop, dreary enough to those to whom they are not (as they have long been to me) a home and a work-field. Those sands are several hundred feet thick. They lie on the London clay. And they represent—the reader must take geologists' word for it—a series of beds in some places thousands of feet thick, in the Isle of Wight, in the Paris basin, in the volcanic country of the Auvergne, in Switzerland, in Italy; a period during which the land must at first have swarmed with forms of tropic life, and then grown—but very gradually—more temperate, and then colder and colder still; till at last set in that age of ice, which spread the boulder pebbles over all rocks and soils indiscriminately, from the Lake mountains to within a few miles of London.

For everywhere about those Ascot moors, the top of the sands has been ploughed by shore-ice in winter, as they lay a-wash in the shallow sea; and over them, in many places, is spread a thin sheet of ice gravel, more ancient, the best geologists think, than the boulder and the boulder-clay.

If any of my readers ask how long the period was during which those sands of Ascot Heath and Aldershot have been laid down, I cannot tell. But this we can tell. It was long enough to see such changes in

land and sea, that maps representing Europe during the greater part of that period (as far as we can guess at it) look no more like Europe than like America or the South Sea Islands. And this we can tell besides: that that period was long enough for the Swiss Alps to be lifted up at least 10,000 feet of their present height. And that was a work which—though God could, if He willed it, have done it in a single day—we have proof positive was not done in less than ages, beside which the mortal life of man is as the life of the gnat which dances in the sun.

And all this, and more—as may be proved from the geology of foreign countries—happened between the date of the boulder-clay, and that of the New Red sandstone on which it rests.

IV.

THE COAL IN THE FIRE.

My dear town-dwelling readers, let me tell you now something of a geological product well known, happily, to all dwellers in towns, and of late years, thanks to railroad extension, to most dwellers in country districts: I mean coal.

Coal, as of course you know, is commonly said to be composed of vegetable matter, of the leaves and stems of ancient plants and trees—a startling statement, and one which I do not wish you to take entirely on trust. I shall therefore spend a few pages in showing you how this fact—for fact it is—was discovered. It is a very good example of reasoning from the known to the unknown. You will have a right to say at first starting, "Coal is utterly different in look from leaves and stems. The only property which they seem to have in common is that they can both burn." True. But difference of mere look may be only owing to a transformation, or series of transformations. There are plenty in nature quite as great, and greater. What can be more different in look, for instance, than

a green field of wheat and a basket of loaves at the baker's? And yet there is, I trust, no doubt whatsoever that the bread has been once green wheat, and that the green wheat has been transformed into bread —making due allowance, of course, for the bone-dust, or gypsum, or alum with which the worthy baker may have found it profitable to adulterate his bread, in order to improve the digestion of Her Majesty's subjects.

But you may say, "Yes, but we can see the wheat growing, flowering, ripening, reaped, ground, kneaded, baked. We see, in the case of bread, the processes of the transformation going on: but in the case of coal we do not see the wood and leaves being actually transformed into coal, or anything like it."

Now suppose we laid out the wheat on a table in a regular series, such as you may see in many exhibitions of manufactures; beginning with the wheat plant at one end, and ending with the loaf at the other; and called in to look at them a savage who knew nothing of agriculture and nothing of cookery —called in, as an extreme case, the man in the moon, who certainly can know nothing of either; for as there is neither air nor water round the moon, there can be nothing to grow there, and therefore nothing to cook —and suppose we asked him to study the series from end to end. Do you not think that the man in the moon, if he were half as shrewd as Crofton Croker makes him in his conversation with Daniel O'Rourke, would answer after due meditation, "How the wheat plant got changed into the loaf I cannot see from my experience in the moon: but that it has been changed, and that the two are the same thing I do see, for I see

all the different stages of the change." And so I think you may say of the wood and the coal.

The man in the moon would be quite reasonable in his conclusion; for it is a law, a rule, and one which you will have to apply again and again in the study of natural objects, that however different two objects may look in some respects, yet if you can find a regular series of gradations between them, with all shades of likeness, first to one of them and then to the other, then you have a fair right to suppose them to be only varieties of the same species, the same kind of thing, and that, therefore, they have a common origin.

That sounds rather magniloquent. Let me give you a simple example.

Suppose you had come into Britain with Brute, the grandson of Æneas, at that remote epoch when (as all archæologists know who have duly read Geoffrey of Monmouth and the Arthuric legends) Britain was inhabited only by a few giants. Now if you had met giants with one head, and also giants with seven heads, and no others, you would have had a right to say, "There are two breeds of giants here, one-headed and seven-headed." But if you had found, as Jack the Giant-Killer (who belongs to the same old cycle of myths) appears to have found, two-headed giants also, and three-headed, and giants, indeed, with any reasonable number of heads, would you not have been justified in saying, "They are all of the same breed, after all; only some are more capitate, or heady, than others!"

I hope that you agree to that reasoning; for by it I think we arrive most surely at a belief in the unity

of the human race, and that the Negro is actually a man and a brother.

If the only two types of men in the world were an extreme white type, like the Norwegians, and an extreme black type, like the Negros, then there would be fair ground for saying, "These two types have been always distinct; they are different races, who have no common origin." But if you found, as you will find, many types of man showing endless gradations between the white man and the Negro, and not only that, but, endless gradations between them both and a third type, whose extreme perhaps is the Chinese—endless gradations, I say, showing every conceivable shade of resemblance or difference, till you often cannot say to what type a given individual belongs; and all of them, however different from each other, more like each other than they are like any other creature upon earth; then you are justified in saying, "All these are mere varieties of one kind. However distinct they are now, they were probably like each other at first, and therefore all probably had a common origin." That seems to me sound reasoning, and advanced natural science is corroborating it more and more daily.

Now apply the same reasoning to coal. You may find about the world—you may see even in England alone—every gradation between coal and growing forest. You may see the forest growing in its bed of vegetable mould; you may see the forest dead and converted into peat, with stems and roots in it; that, again, into sunken forests, like those to be seen below high-water mark on many coasts of this island. You find gradations between them and beds of lignite, or wood coal; then gradations between lignite and

common or bituminous coal; and then gradations between common coal and culm, or anthracite, such as is found in South Wales. Have you not a right to say, "These are all but varieties of the same kind of thing —namely, vegetable matter? They have a common origin—namely, woody fibre. And coal, or rather culm, is the last link in a series of transformations from growing vegetation?"

This is our first theory. Let us try to verify it, as scientific men are in the habit of doing, by saying, If that be true, then something else is likely to be true too.

If coal has all been vegetable soil, then it is likely that some of it has not been quite converted into shapeless coal. It is likely that there will be vegetable fibre still to be seen here and there; perhaps leaves, perhaps even stems of trees, as in a peat bog. Let us look for them.

You will not need to look far. The coal, and the sands and shales which accompany the coal, are so full of plant-remains, that three hundred species were known to Adolphe Brongniart as early as 1849, and that number has largely increased since.

Now one point is specially noticeable about these plants of the coal; namely, that they may at least have grown in swamps.

First, you will be interested if you study the coal flora, with the abundance, beauty, and variety of the ferns. Now ferns in these islands grow principally in rocky woods, because there, beside the moisture, they get from decaying vegetable or decaying rock, especially limestone, the carbonic acid which is their special food, and which they do not get on our dry pastures,

and still less in our cultivated fields. But in these islands there are two noble species, at least, which are true swamp-ferns; the Lastræa Thelypteris, which of old filled the fens, but is now all but extinct; and the Osmunda, or King-fern, which, as all know, will grow wherever it is damp enough about the roots. In Hampshire, in Devon, and Cornwall, and in the south-west of Ireland, the King-fern too is a true swamp fern. But in the Tropics I have seen more than once noble tree-ferns growing in wet savannahs at the sea-level, as freely as in the mountain-woods; ferns with such a stem as some of the coal ferns had, some fifteen feet in height, under which, as one rode on horseback, one saw the blazing blue sky, as through a parasol of delicate lace, as men might have long ages since have seen it, through the plumed fronds of the ferns now buried in the coal, had there only been a man then created to enjoy its beauty.

Next we find plants called by geologists Calamites. There is no doubt now that they are of the same family as our Equiseta, or horse-tails, a race which has, over most parts of the globe, dwindled down now from twenty or thirty feet in height, as they were in the old coal measures, to paltry little weeds. The tallest Equisetum in England—the beautiful E. Telmateia—is seldom five feet high. But they, too, are mostly mud and swamp plants; and so may the Calamites have been.

The Lepidodendrons, again, are without doubt the splendid old representatives of a family now dwindled down to such creeping things as our club-mosses, or Lycopodiums. Now it is a certain fact, which can be proved by the microscope, that a very great part of the

best coal is actually made up of millions of the minute seeds of club-mosses, such as grow—a few of them, and those very small—on our moors; a proof, surely, not only of the vast amount of the vegetation in the coal-making age, but also of the vast time during which it lasted. The Lepidodendra may have been fifty or sixty feet high. There is not a Lycopodium in the world now, I believe, five feet high. But the club-mosses are now, in these islands and elsewhere, lovers of wet and peaty soils, and so may their huger prototypes have been, in the old forests of the coal.

Of the Sigillariæ we cannot say as much with certainty, for botanists are not agreed as to what low order of flowerless plants they belong. But that they rooted in clay beds there is proof, as you will hear presently.

And as to the Conifers, or pine-like trees—the Dadoxylon, of which the pith goes by the name of Sternbergia, and the uncertain tree which furnishes in some coal-measures bushels of a seed connected with that of the yew—we may suppose that they would find no more difficulty in growing in swamps than the cypress, which forms so large a portion of the vegetation in the swamps of the Southern United States.

I have given you these hints, because you will naturally wish to know what sort of a world it was in which all these strange plants grew and turned into coal.

My answer is, that it was most probably just like the world in which we are living now, with the one exception that the plants and animals are different.

It was the fashion, a few years since to explain the coal—like other phenomena of geology—by some mere

hypothesis of a state of things quite unlike what we see now. We were brought up to believe that in the Carboniferous, or coal-bearing era, the atmosphere was intensely moist and hot, and overcharged with carbonic acid, which had been poured out from the interior of the planet by volcanic eruptions, or by some other convulsion. I forget most of it now: and really there is no need to remember; for it is all, I verily believe, a dream—an attempt to explain the unknown not by the known, but by the still more unknown. You may find such theories lingering still in sensational school-books, if you like to be unscientific. If you like, on the other hand, to be scientific you will listen to those who tell you that instead of there having been one unique carboniferous epoch, with a peculiar coal-making climate, all epochs are carboniferous if they get the chance; that coal is of every age, from that of the Scotch and English beds, up to the present day. The great coal-beds along the Rocky Mountains, for instance, are tertiary—that is, later than the chalk. Coal is forming now, I doubt not, in many places on the earth, and would form in many more, if man did not interfere with the processes of wild nature, by draining the fens, and embanking the rivers.

Let me by a few words prove this statement. They will give you, beside, a fresh proof of Sir Charles Lyell's great geological rule—that the best way to explain what we see in ancient rocks is to take for granted, as long as we can do so fairly, that things were going on then very much as they are going on now.

When it was first seen that coal had been once vegetable, the question arose—How did all these huge

masses of vegetable matter get there? The Yorkshire and Derbyshire coal-fields, I hear, cover 700 or 800 square miles; the Lancashire about 200. How large the North Wales and the Scotch fields are I cannot say. But doubtless a great deal more coal than can be got at lies under the sea, especially in the north of Wales. Coal probably exists over vast sheets of England and France, buried so deeply under later rocks, that it cannot be reached by mining. As an instance, a distinguished geologist has long held that there are beds of coal under London itself, which rise, owing to a peculiar disturbance of the strata, to within 1,000 or 1,200 feet of the surface, and that we or our children may yet see coal-mines in the marshes of the Thames. And more, it is a provable fact that only a portion of the coal measures is left. A great part of Ireland must once have been covered with coal, which is now destroyed. Indeed, it is likely that the coal now known of in Europe and America is but a remnant of what has existed there in former ages, and has been eaten away by the inroads of the sea.

Now whence did all that enormous mass of vegetable soil come? Off some neighbouring land, was the first and most natural answer. It was a rational one. It proceeded from the known to the unknown. It was clear that these plants had grown on land; for they were land-plants. It was clear that there must have been land close by, for between the beds of coal, as you all know, the rock is principally coarse sandstone, which could only have been laid down (as I have explained to you already) in very shallow water.

It was natural, then, to suppose that these plants and trees had been swept down by rivers into the sea,

as the sands and muds which buried them had been. And it was known that at the mouths of certain rivers —the Mississippi, for instance—vast rafts of dead floating trees accumulated; and that the bottoms of the rivers were often full of snags, etc.; trees which had grounded, and stuck in the mud; and why should not the coal have been formed in the same way?

Because—and this was a serious objection—then surely the coal would be impure—mixed up with mud and sand, till it was not worth burning. Instead of which, the coal is usually pure vegetable, parted sharply from the sandstone which lies on it. The only other explanation was, that the coal vegetation had grown in the very places where it was found. But that seemed too strange to be true, till that great geologist, Sir W. Logan—who has since done such good work in Canada—showed that every bed of coal had a bed of clay under it, and that that clay always contained fossils called Stigmaria. Then it came out that the Stigmaria in the under clay had long filaments attached to them, while when found in the sandstones or shales, they had lost their filaments, and seemed more or less rolled—in fact, that the natural place of the Stigmaria was in the under clay. Then Mr. Binney discovered a tree—a Sigillaria, standing upright in the coal-measures with its roots attached. Those roots penetrated into the under clay of the coal; and those roots were Stigmarias. That seems to have settled the question. The Sigillarias, at least, had grown where they were found, and the clay beneath the coal-beds was the original soil on which they had grown. Just so, if you will look at any peat bog you will find it bottomed by clay, which clay

is pierced everywhere by the roots of the moss forming the peat, or of the trees, birches, alders, poplars, and willows, which grow in the bog. So the proof seemed complete, that the coal had been formed out of vegetation growing where it was buried. If any further proof for that theory was needed, it would be found in this fact, most ingeniously suggested by Mr. Boyd Dawkins. The resinous spores, or seeds of the Lepidodendra make up—as said above—a great part of the bituminous coal. Now those spores are so light, that if the coal had been laid down by water, they would have floated on it, and have been carried away; and therefore the bituminous coal must have been formed, not under water, but on dry land.

I have dwelt at length on these further arguments, because they seem to me as pretty a specimen as I can give my readers of that regular and gradual induction, that common-sense regulated, by which geological theories are worked out.

But how does this theory explain the perfect purity of the coal? I think Sir C. Lyell answers that question fully in p. 383 of his "Student's Elements of Geology." He tells us that the dense growths of reeds and herbage which encompass the margins of forest-covered swamps in the valley and delta of the Mississippi, in passing through them, are filtered and made to clear themselves entirely before they reach the areas in which vegetable matter may accumulate for centuries, forming coal if the climate be favourable; and that in the cypress-swamps of that region no sediment mingles with the vegetable matter accumulated from the decay of trees and semi-aquatic plants; so that when, in a very dry season, the swamp

is set on fire, pits are burnt into the ground many feet deep, or as far as the fire can go down without reaching water, and scarcely any earthy residuum is left; just as when the soil of the English fens catches fire, red-hot holes are eaten down through pure peat till the water-bearing clay below is reached. But the purity of the water in peaty lagoons is observable elsewhere than in the delta of the Mississippi. What can be more transparent than many a pool surrounded by quaking bogs, fringed, as they are in Ireland, with a ring of white water-lilies, which you dare not stoop to pick, lest the peat, bending inward, slide you down into that clear dark gulf some twenty feet in depth, bottomed and walled with yielding ooze, from which there is no escape? Most transparent, likewise, is the water of the West Indian swamps. Though it is of the colour of coffee, or rather of dark beer, and so impregnated with gases that it produces fever or cholera when drunk, yet it is—at least when it does not mingle with the salt water—so clear, that one might see every marking on a boa-constrictor or alligator, if he glided along the bottom under the canoe.

But now comes the question—Even if all this be true, how were the forests covered up in shale and sandstone, one after another?

By gradual sinking of the land, one would suppose.

If we find, as we may find in a hundred coal-pits, trees rooted as they grew, with their trunks either standing up through the coal, and through the sandstone above the coal; their bark often remaining as coal while their inside is filled up with sandstone, has not our common-sense a right to say—The land on

which they grew sank below the water-line; the trees were killed; and the mud and sand which were brought down the streams enveloped their trunks? As for the inside being full of sandstone, have we not all seen hollow trees? Do we not all know that when a tree dies its wood decays first, its bark last? It is so, especially in the Tropics. There one may see huge dead trees with their bark seemingly sound, and their inside a mere cavern with touchwood at the bottom; into which caverns one used to peep with some caution. For though one might have found inside only a pair of toucans, or parrots, or a whole party of jolly little monkeys, one was quite as likely to find a poisonous snake four or five feet long, whose bite would have very certainly prevented me having the pleasure of writing this book.

Now is it not plain that if such trees as that sunk, their bark would be turned into lignite, and at last into coal, while their insides would be silted up with mud and sand? Thus a core or pillar of hard sandstone would be formed, which might do to the collier of the future what they are too apt to do now in the Newcastle and Bristol collieries. For there, when the coal is worked out below, the sandstone stems—"coal-pipes" as the colliers call them—in the roof of the seam, having no branches, and nothing to hold them up but their friable bark of coal, are but too apt to drop out suddenly, killing or wounding the hapless men below.

Or again, if we find—as we very often find—as was found at Parkfield Colliery, near Wolverhampton, in the year 1844—a quarter of an acre of coal-seam filled with stumps of trees as they grew, their trunks broken

off and lying in every direction, turned into coal, and flattened, as coal-fossils so often are, by the weight of the rock above—should we not have a right to say—These trees were snapped off where they grew by some violent convulsion; by a storm, or by a sudden inrush of water owing to a sudden sinking of the land, or by the very earthquake shock itself which sank the land?

But what evidence have we of such sinkings? The plain fact that you have coal-seam above coal-seam, each with its bed of under-clay; and that therefore the land *must* have sunk ere the next bed of soil could have been deposited, and the next forest have grown on it.

In one of the Rocky Mountain coal-fields there are more than thirty seams of coal, each with its under-clay below it. What can that mean but thirty or more subsidences of the land, and the peat of thirty or more forests or peat-mosses, one above the other? And now if any reader shall say, Subsidence? What is this quite new element which you have brought into your argument? You told us that you would reason from the known to the unknown. What do we know of subsidence? You offered to explain the thing which had gone on once by that which is going on now. Where is subsidence going on now upon the surface of our planet? And where, too, upheaval, such as would bring us these buried forests up again from under the sea-level, and make them, like our British coal-field, dry land once more?

The answer is—Subsidence and elevation of the land are common now, probably just as common as they were in any age of this planet's history.

To give two instances, made now notorious by the writings of geologists. As lately as 1819 a single earthquake shock in Cutch, at the mouth of the Indus, sunk a tract of land larger than the Lake of Geneva in some places to a depth of eighteen feet, and converted it into an inland sea. The same shock raised, a few miles off, a corresponding sheet of land some fifty miles in length, and in some parts sixteen miles broad, ten feet above the level of the alluvial plain, and left it to be named by the country-people the "Ullah Bund," or bank of God, to distinguish it from the artificial banks in the neighbourhood.

Again: in the valley of the Mississippi—a tract which is now, it would seem, in much the same state as central England was while our coal-fields were being laid down—the earthquakes of 1811–12 caused large lakes to appear suddenly in many parts of the district, amid the dense forests of cypress. One of these, the "Sunk Country," near New Madrid, is between seventy and eighty miles in length, and thirty miles in breadth, and throughout it, as late as 1846, "dead trees were conspicuous, some erect in the water, others fallen, and strewed in dense masses over the bottom, in the shallows, and near the shore." I quote these words from Sir Charles Lyell's "Principles of Geology" (11th edit.), vol. i. p. 453. And I cannot do better than advise my readers, if they wish to know more of the way in which coal was formed, to read what is said in that book concerning the Delta of the Mississippi, and its strata of forests sunk where they grew, and in some places upraised again, alternating with beds of clay and sand, vegetable soil, recent sea-shells, and what not, forming, to

a depth of several hundred feet, just such a mass of beds as exists in our own coal-fields at this day.

If, therefore, the reader wishes to picture to himself the scenery of what is now central England, during the period when our coal was being laid down, he has only, I believe, to transport himself in fancy to any great alluvial delta, in a moist and warm climate, favourable to the growth of vegetation. He has only to conceive wooded marshes, at the mouth of great rivers, slowly sinking beneath the sea; the forests in them killed by the water, and then covered up by layers of sand, brought down from inland, till that new layer became dry land, to carry a fresh crop of vegetation. He has thus all that he needs to explain how coal-measures were formed. I myself saw once a scene of that kind, which I should be sorry to forget; for there was, as I conceived, coal, making, or getting ready to be made, before my eyes: a sheet of swamp, sinking slowly into the sea; for there stood trees, still rooted below high-water mark, and killed by the waves; while inland huge trees stood dying, or dead, from the water at their roots. But what a scene—a labyrinth of narrow creeks, so narrow that a canoe could not pass up, haunted with alligators and boa-constrictors, parrots and white herons, amid an inextricable confusion of vegetable mud, roots of the alder-like mangroves, and tangled creepers hanging from tree to tree; and overhead huge fan-palms, delighting in the moisture, mingled with still huger broad-leaved trees in every stage of decay. The drowned vegetable soil of ages beneath me; above my head, for a hundred feet, a mass of stems and boughs, and leaves and flowers, compared with which the richest hothouse

in England was poor and small. But if the sinking process which was going on continued a few hundred years, all that huge mass of wood and leaf would be sunk beneath the swamp, and covered up in mud washed down from the mountains, and sand driven in from the sea; to form a bed many feet thick, of what would be first peat, then lignite, and last, it may be, coal, with the stems of killed trees standing up out of it into the new mud and sand-beds above it, just as the Sigillariæ and other stems stand up in the coal-beds both of Britain and of Nova Scotia; while over it a fresh forest would grow up, to suffer the same fate —if the sinking process went on—as that which had preceded it.

That was a sight not easily to be forgotten. But we need not have gone so far from home, at least, a few hundred years ago, to see an exactly similar one. The fens of Norfolk and Cambridgeshire, before the rivers were embanked, the water pumped off, the forests felled, and the reed-beds ploughed up, were exactly in the same state. The vast deposits of peat between Cambridge and the sea, often filled with timber-trees, either fallen or upright as they grew, and often mixed with beds of sand or mud, brought down in floods, were formed in exactly the same way; and if they had remained undrained, then that slow sinking, which geologists say is going on over the whole area of the Fens, would have brought them gradually, but surely, below the sea-level, to be covered up by new forests, and converted in due time into coal. And future geologists would have found—they may find yet, if, which God forbid, England should become barbarous and the trees be thrown out

of cultivation—instead of fossil Lepidodendra and Sigillariæ, Calamites and ferns, fossil ashes and oaks, alders and poplars, bulrushes and reeds. Almost the only fossil fern would have been that tall and beautiful Lastræa Thelypteris, once so abundant, now all but destroyed by drainage and the plough.

We need not, therefore, fancy any extraordinary state of things on this planet while our English coal was being formed. The climate of the northern hemisphere—Britain, at least, and Nova Scotia—was warmer than now, to judge from the abundance of ferns; and especially of tree-ferns; but not so warm, to judge from the presence of conifers (trees of the pine tribe), as the Tropics. Moreover, there must have been, it seems to me, a great scarcity of animal life. Insects are found, beautifully preserved; a few reptiles, too, and land-shells; but very few. And where are the traces of such a swarming life as would be entombed were a tropic forest now sunk; which is found entombed in many parts of our English fens? The only explanation which I can offer is this—that the club-mosses, tree-ferns, pines, and other low-ranked vegetation of the coal afforded little or no food for animals, as the same families of plants do to this day; and if creatures can get nothing to eat, they certainly cannot multiply and replenish the earth. But, be that as it may, the fact that coal is buried forest is not affected.

Meanwhile, the shape and arrangements of sea and land must have been utterly different from what they are now. Where was that great land, off which great rivers ran to deposit our coal-measures in their deltas? It has been supposed, for good reasons, that

north-western France, Belgium, Holland, and Germany were then under the sea; that Denmark and Norway were joined to Scotland by a continent, a tongue of which ran across the centre of England, and into Ireland, dividing the northern and southern coal-fields. But how far to the west and north did that old continent stretch? Did it, as it almost certainly did long ages afterwards, join Greenland and North America with Scotland and Norway? Were the northern fields of Nova Scotia, which are of the same geological age as our own, and contain the same plants, laid down by rivers which ran off the same continent as ours? Who can tell now? That old land, and all record of it, save what these fragmentary coal-measures can give, are buried in the dark abyss of countless ages; and we can only look back with awe, and comfort ourselves with the thought—Let Time be ever so vast, yet Time is not Eternity.

One word more. If my readers have granted that all for which I have argued is probable, they will still have a right to ask for further proof.

They will be justified in saying: "You say that coal is transformed vegetable matter; but can you show us how the transformation takes place? Is it possible according to known natural laws?"

The chemist must answer that. And he tells us that wood can become lignite, or wood-coal, by parting with its oxygen, in the shape of carbonic acid gas, or choke-damp; and then common or bituminous coal, by parting with its hydrogen, chiefly in the form of carburetted hydrogen—the gas with which we light our streets. That is about as much as the unscientific reader need know. But it is a fresh corroboration of

the theory that coal has been once vegetable fibre, for it shows how vegetable fibre can, by the laws of nature, become coal. And it certainly helps us to believe that a thing has been done, if we are shown that it can be done.

This fact explains, also, why in mines of wood-coal carbonic acid, *i.e.* choke-damp, alone is given off. For in the wood-coal a great deal of the hydrogen still remains. In mines of true coal, not only is choke-damp given off, but that more terrible pest of the miners, fire-damp, or explosive carburetted hydrogen and olefiant gases. Now the occurrence of that fire-damp in mines proves that changes are still going on in the coal: that it is getting rid of its hydrogen, and so progressing toward the state of anthracite or culm —stone-coal as it is sometimes called. In the Pennsylvanian coal-fields some of the coal has actually done this, under the disturbing force of earthquakes; for the coal, which is bituminous, like our common coal, to the westward where the strata are horizontal, becomes gradually anthracite as it is tossed and torn by the earthquake faults of the Alleghany and Appalachian mountains.

And is a further transformation possible? Yes; and more than one. If we conceive the anthracite cleared of all but its last atoms of oxygen, hydrogen, and nitrogen, till it has become all but pure carbon, it would become—as it has become in certain rocks of immense antiquity, graphite—what we miscall black-lead. And, after that, it might go through one transformation more, and that the most startling of all. It would need only perfect purification and crystallisation to become—a diamond; nothing less. We

may consider the coal upon the fire as the middle term of a series, of which the first is live wood, and the last diamond; and indulge safely in the fancy that every diamond in the world has probably, at some remote epoch, formed part of a growing plant.

A strange transformation; which will look to us more strange, more truly poetical, the more steadily we consider it.

The coal on the fire; the table at which I write—what are they made of? Gas and sunbeams; with a small percentage of ash, or earthy salts, which need hardly be taken into account.

Gas and sunbeams. Strange, but true.

The life of the growing plant—and what that life is who can tell?—laid hold of the gases in the air and in the soil; of the carbonic acid, the atmospheric air, the water—for that too is gas. It drank them in through its rootlets: it breathed them in through its leaf-pores, that it might distil them into sap, and bud, and leaf, and wood. But it has to take in another element, without which the distillation and the shaping could never have taken place. It had to drink in the sunbeams—that mysterious and complex force which is for ever pouring from the sun, and making itself partly palpable to our senses as heat and light. So the life of the plant seized the sunbeams, and absorbed them, buried them in itself—no longer as light and heat, but as invisible chemical force, locked up for ages in that woody fibre.

So it is. Lord Lytton told us long ago, in a beautiful song, how

The Wind and the Beam loved the Rose.

But Nature's poetry was more beautiful than man's. The wind and the beam loved the rose so well that they made the rose—or rather, the rose took the wind and the beam, and built up out of them, by her own inner life, her exquisite texture, hue, and fragrance.

What next? The rose dies; the timber tree dies; decays down into vegetable fibre, is buried, and turned to coal: but the plant cannot altogether undo its own work. Even in death and decay it cannot set free the sunbeams imprisoned in its tissue. The sun-force must stay, shut up age after age, invisible, but strong; working at its own prison-cells; transmuting them, or making them capable of being transmuted by man, into the manifold products of coal—coke, petroleum, mineral pitch, gases, coal-tar, benzole, delicate aniline dyes, and what not, till its day of deliverance comes.

Man digs it, throws it on the fire, a black, dead-seeming lump. A corner, an atom of it, warms till it reaches the igniting point; the temperature at which it is able to combine with oxygen.

And then, like a dormant live thing, awaking after ages to the sense of its own powers, its own needs, the whole lump is seized, atom after atom, with an infectious hunger for that oxygen which it lost centuries since in the bottom of the earth. It drinks the oxygen in at every pore; and burns.

And so the spell of ages is broken. The sun-force bursts its prison-cells, and blazes into the free atmosphere, as light and heat once more; returning in a moment into the same forms in which it entered the growing leaf a thousand centuries since.

Strange it all is, yet true. But of nature, as of the heart of man, the old saying stands—that truth is stranger than fiction.

V.

THE LIME IN THE MORTAR.

I SHALL presume in all my readers some slight knowledge about lime. I shall take for granted, for instance, that all are better informed than a certain party of Australian black fellows were a few years since.

In prowling on the track of a party of English settlers, to see what they could pick up, they came—oh joy!—on a sack of flour, dropped and left behind in the bush at a certain creek. The poor savages had not had such a prospect of a good meal for many a day. With endless jabbering and dancing, the whole tribe gathered round the precious flour-bag with all the pannikins, gourds, and other hollow articles it could muster, each of course with a due quantity of water from the creek therein, and the chief began dealing out the flour by handfuls, beginning of course with the boldest warriors. But, horror of horrors, each man's porridge swelled before his eyes, grew hot, smoked, boiled over. They turned and fled, man, woman, and child, from before that supernatural

prodigy; and the settlers coming back to look for the dropped sack, saw a sight which told the whole tale. For the poor creatures, in their terror, had thrown away their pans and calabashes, each filled with that which it was likely to contain, seeing that the sack itself had contained, not flour, but quick-lime. In memory of which comi-tragedy, that creek is called to this day, "Flour-bag Creek."

Now I take for granted that you are all more learned than these black fellows, and know quick-lime from flour. But still you are not bound to know what quick-lime is. Let me explain it to you.

Lime, properly speaking, is a metal, which goes among chemists by the name of calcium. But it is formed, as you all know, in the earth, not as a metal, but as a stone, as chalk or limestone, which is a carbonate of lime; that is, calcium combined with oxygen and carbonic-acid gases.

In that state it will make, if it is crystalline and hard, excellent building stone. The finest white marble, like that of Carrara in Italy, of which the most delicate statues are carved, is carbonate of lime altered and hardened by volcanic heat. But to make mortar of it, it must be softened and then brought into a state in which it can be hardened again; and ages since, some man or other, who deserves to rank as one of the great inventors, one of the great benefactors of his race, discovered the art of making lime soft and hard again; in fact of making mortar. The discovery was probably very ancient; and made, probably like most of the old discoveries, in the East, spreading Westward gradually. The earlier Greek buildings are cyclopean, that is, of stone fitted together without mortar. The

earlier Egyptian buildings, though the stones are exquisitely squared and polished, are put together likewise without mortar. So, long ages after, were the earlier Roman buildings, and even some of the later. The famous aqueduct of the Pont du Gard, near Nismes, in the south of France, has, if I recollect right, no mortar whatever in it. The stones of its noble double tier of circular arches have been dropped into their places upon the wooden centres, and stand unmoved to this day, simply by the jamming of their own weight; a miracle of art. But the fact is puzzling; for these Romans were the best mortar makers of the world. We cannot, I believe, surpass them in the art even now; and in some of their old castles, the mortar is actually to this day harder and tougher than the stones which it holds together. And they had plenty of lime at hand if they had chosen to make mortar. The Pont du Gard crosses a limestone ravine, and is itself built of limestone. But I presume the cunning Romans would not trust mortar made from that coarse Nummulite limestone, filled with gritty sand, and preferred, with their usual carefulness, no mortar at all to bad.

But I must return, and tell my readers, in a few words, the chemical history of mortar. If limestone be burnt, or rather roasted, in a kiln, the carbonic acid is given off—as you may discover by your own nose; as many a poor tramp has discovered too late, when, on a cold winter night, he has lain down by the side of the burning kiln to keep himself warm, and woke in the other world, stifled to death by the poisonous fumes.

The lime then gives off its carbonic acid, and also

its water of crystallisation, that is, water which it holds (as do many rocks) locked up in it unseen, and only to be discovered by chemical analysis. It is then anhydrous—that is, waterless—oxide of lime, what we call quick-lime; that which figured in the comi-tragedy of "Flour-bag Creek;" and then, as you may find if you get it under your nails or into your eyes, will burn and blister like an acid.

This has to be turned again into a hard and tough artificial limestone, in plain words, into mortar; and the first step is to slack it—that is, to give it back the water which it has lost, and for which it is as it were thirsting. So it is slacked with water, which it drinks in, heating itself and the water till it steams and swells in bulk, because it takes the substance of the water into its own substance. Slacked lime, as we all know, is not visibly wetter than quick-lime; it crumbles to a dry white powder in spite of all the water which it contains.

Then it must be made to set, that is, to return to limestone, to carbonate of lime, by drinking in the carbonic acid from water and air, which some sorts of lime will do instantly, setting at once, and being therefore used as cements. But the lime usually employed must be mixed with more or less sand to make it set hard: a mysterious process, of which it will be enough to tell the reader that the sand and lime are said to unite gradually, not only mechanically, that is, by sticking together; but also in part chemically—that is, by forming out of themselves a new substance, which is called silicate of lime.

Be that as it may, the mortar paste has now to do two things; first to dry, and next to take up carbonic

acid from the air and water, enough to harden it again into limestone: and that it will take some time in doing. A thick wall, I am informed, requires several years before it is set throughout, and has acquired its full hardness, or rather toughness; and good mortar, as is well known, will acquire extreme hardness with age, probably from the very same cause that it did when it was limestone in the earth. For, as a general rule, the more ancient the strata is in which the limestone is found, the harder the limestone is; except in cases where volcanic action and earthquake pressure have hardened limestone in more recent strata, as in the case of the white marbles of Carrara in Italy, which are of the age of our Oolites, that is, of the freestone of Bath, etc., hardened by the heat of intruded volcanic rocks.

But now: what is the limestone? and how did it get where it is—not into the mortar, I mean, but into the limestone quarry? Let me tell you, or rather, help you to tell yourselves, by leading you, as before, from the known to the unknown. Let me lead you to places unknown indeed to most; but there may be sailors or soldiers among my readers who know them far better than I do. Let me lead you, in fancy, to some island in the Tropic seas. After all, I am not leading you as far away as you fancy by several thousand miles, as you will see, I trust, ere I have done.

Let me take you to some island: what shall it be like? Shall it be a high island, with cliff piled on cliff, and peak on peak, all rich with mighty forests, like a furred mantle of green velvet, mounting up and up till it is lost among white clouds above? Or shall it

be a mere low reef, which you do not see till you are close upon it; on which nothing rises above the water, but here and there a knot of cocoa-nut palms or a block of stone, or a few bushes, swarming with innumerable sea-fowl and their eggs? Let it be which you will: both are strange enough; both beautiful; both will tell us a story.

The ship will have to lie-to, and anchor if she can; it may be a mile, it may be only a few yards, from the land. For between it and the land will be a line of breakers, raging in before the warm trade-wind. And this, you will be told, marks the edge of the coral reef.

You will have to go ashore in a boat, over a sea which looks unfathomable, and which may be a mile or more in depth, and search for an opening in the reef, through which the boat can pass without being knocked to pieces.

You find one: and in a moment, what a change! The deep has suddenly become shallow; the blue white, from the gleam of the white coral at the bottom. But the coral is not all white, only indeed a little of it; for as you look down through the clear water, you find that the coral is starred with innumerable live flowers, blue, crimson, grey, every conceivable hue; and that these are the coral polypes, each with its ring of arms thrust out of its cell, who are building up their common habitations of lime. If you want to understand, by a rough but correct description, what a coral polype is: all who have been to the sea-side know, or at least have heard of, sea-anemones. Now coral polypes are sea-anemones, which make each a shell of lime, growing with its growth. As for their shapes, the variety of them, the beauty of them, no tongue can describe

them. If you want to see them, go to the Coral Rooms of the British or Liverpool Museums, and judge for yourselves. Only remember that you must re-clothe each of those exquisite forms with a coating of live jelly of some delicate hue, and put back into every one of the thousand cells its living flower; and into the beds, or rather banks, of the salt-water flower garden, the gaudiest of shell-less sea-anemones, such as we have on our coasts, rooted in the cracks, and live shells and sea-slugs, as gaudy as they, crawling about, with fifty other forms of fantastic and exuberant life. You must not overlook, too, the fish, especially the parrot-fish, some of them of the gaudiest colours, who spend their lives in browsing on the live coral, with strong clipping and grinding teeth, just as a cow browses the grass, keeping the animal matter, and throwing away the lime in the form of an impalpable white mud, which fills up the interstices in the coral beds.

The bottom, just outside the reef, is covered with that mud, mixed with more lime-mud, which the surge wears off the reef; and if you have, as you should have, a dredge on board, and try a haul of that mud as you row home, you may find, but not always, animal forms rooted in it, which will delight the soul of a scientific man. One, I hope, would be some sort of Terebratula, or shell akin to it. You would probably think it a cockle: but you would be wrong. The animal which dwells in it has about the same relationship to a cockle as a dog has to a bird. It is a Brachiopod; a family with which the ancient seas once swarmed, but which is rare now, all over the world, having been supplanted and driven out of the seas by newer and stronger forms of shelled animals. The nearest spot at which you are

likely to dredge a live Brachiopod will be in the deep water of Loch Fyne, in Argyleshire, where two species still linger, fastened, strangely enough, to the smooth pebbles of a submerged glacier, formed in the open air during the age of ice, but sunk now to a depth of eighty fathoms. The first time I saw those shells come up in the dredge out of the dark and motionless abyss, I could sympathise with the feelings of mingled delight and awe which, so my companion told me, the great Professor Owen had in the same spot first beheld the same lingering remnants of a primæval world.

The other might be (but I cannot promise you even a chance of dredging that, unless you were off the coast of Portugal, or the windward side of some of the West India Islands) a live Crinoid; an exquisite starfish, with long and branching arms, but rooted in the mud by a long stalk, and that stalk throwing out barren side branches; the whole a living plant of stone. You may see in museums specimens of this family, now so rare, all but extinct. And yet fifty or a hundred different forms of the same type swarmed in the ancient seas: whole masses of limestone are made up of little else but the fragments of such animals.

But we have not landed yet on the dry part of the reef. Let us make for it, taking care meanwhile that we do not get our feet cut by the coral, or stung as by nettles by the coral insects. We shall see that the dry land is made up entirely of coral, ground and broken by the waves, and hurled inland by the storm, sometimes in huge boulders, mostly as fine mud; and that, under the influence of the sun and of the rain, which filters through it, charged with lime from the rotting

coral, the whole is setting, as cement sets, into rock. And what is this? A long bank of stone standing up as a low cliff, ten or twelve feet above high-water mark. It is full of fragments of shell, of fragments of coral, of all sorts of animal remains; and the lower part of it is quite hard rock. Moreover, it is bedded in regular layers, just such as you see in a quarry. But how did it get there? It must have been formed at the sea-level, some of it, indeed, under the sea; for here are great masses of madrepore and limestone corals imbedded just as they grew. What lifted it up? Your companions, if you have any who know the island, have no difficulty in telling you. It was hove up, they say, in the earthquake in such and such a year; and they will tell you, perhaps, that if you will go on shore to the main island which rises inside the reef, you may see dead coral beds just like these lying on the old rocks, and sloping up along the flanks of the mountains to several hundred feet above the sea. I have seen such many a time.

Thus you find the coral being converted gradually into a limestone rock, either fine and homogeneous, composed of coral grown into pulp, or filled with corals and shells, or with angular fragments of older coral rock. Did you never see that last? No? Yes, you have a hundred times. You have but to look at the marbles commonly used about these islands, with angular fragments imbedded in the mass, and here and there a shell, the whole cemented together by water holding in solution carbonate of lime, and there see the very same phenomenon perpetuated to this day.

Thus, I think, we have got first from the known to the unknown; from a tropic coral island back here to

the limestone hills of Great Britain; and I did not speak at random when I said that I was not leading you away as far as you fancied by several thousand miles.

Examine any average limestone quarry from Bristol to Berwick, and you will see there all that I have been describing; that is, all of it which is not soft animal matter, certain to decay. You will see the lime-mud hardened into rock beds; you will see the shells embedded in it; you will see the corals in every stage of destruction; you will see whole layers made up of innumerable fragments of Crinoids—no wonder they are innumerable, for, it has been calculated, there are in a single animal of some of the species 140,000 joints—140,000 bits of lime to fall apart when its soft parts decay. But is it not all there? And why should it not have got there by the same process by which similar old coral beds get up the mountain sides in the West Indies and elsewhere; namely, by the upheaving force of earthquakes? When you see similar effects, you have a right to presume similar causes. If you see a man fall off a house here, and break his neck; and some years after, in London or New York, or anywhere else, find another man lying at the foot of another house, with his neck broken in the same way, is it not a very fair presumption that he has fallen off a house likewise?

You may be wrong. He may have come to his end by a dozen other means: but you must have proof of that. You will have a full right, in science and in common sense, to say—That man fell off the house, till some one proves to you that he did not.

In fact, there is nothing which you see in the lime-

stones of these isles—save and except the difference in every shell and coral—which you would not see in the coral-beds of the West Indies, if such earthquakes as that famous one at St. Thomas's, in 1866, became common and periodic, upheaving the land (they needs upheave it a very little, only two hundred and fifty feet), till St. Thomas's, and all the Virgin Isles, and the mighty mountain of Porto Rico, which looms up dim and purple to the west, were all joined into dry land once more, and the lonely coral-shoal of Anegada were raised, as it would be raised then, into a limestone table-land, like that of Central Ireland, of Galway, or of County Clare.

But you must clearly understand, that however much these coralline limestones have been upheaved since they were formed, yet the sea-bottom, while they were being formed, was sinking and not rising. This is a fact which was first pointed out by Mr. Darwin, from the observations which he made in the world-famous Voyage of the *Beagle*; and the observations of subsequent great naturalists have all gone to corroborate his theory.

It was supposed at first, you must understand, that when a coral island rose steeply to the surface of the sea out of blue water, perhaps a thousand fathoms or more, that fact was plain proof that the little coral polypes had begun at the bottom of the sea, and, in the course of ages, built up the whole island an enormous depth.

But it soon came out that that theory was not correct; for the coral polypes cannot live and build save in shallow water—say in thirty to forty fathoms. Indeed, some of the strongest and largest species work

best at the very surface, and in the cut of the fiercest surf. And so arose a puzzle as to how coral rock is often found of vast thickness, which Mr. Darwin explained. His theory was, and there is no doubt now that it is correct, that in these cases the sea-bottom is sinking; that as it sinks, carrying the coral beds down with it, the coral dies, and a fresh live crop of polypes builds on the top of the houses of their dead ancestors: so that, as the depression goes on, generation after generation builds upwards, the living on the dead, keeping the upper surface of the reef at the same level, while its base is sinking downward into the abyss.

Applying this theory to the coral reef of the Pacific Ocean, the following interesting facts were made out:

That where you find an Island rising out of deep water, with a ring of coral round it, a little way from the shore—or, as in Eastern Australia, a coast with a fringing reef (the Flinders reef of Australia is eleven thousand miles long)—that is a pretty sure sign that that shore, or mountain, is sinking slowly beneath the sea. That where you find, as you often do in the Pacific, a mere atoll, or circular reef of coral, with a shallow pond of smooth water in the centre, and deep sea round, that is a pretty sure sign that the mountain-top has sunk completely into the sea, and that the corals are going on building where its peak once was.

And more. On working out the geography of the South Sea Islands by the light of this theory of Mr. Darwin's, the following extraordinary fact has been discovered:

That over a great part of the Pacific Ocean sinking is going on, and has been going on for ages; and that

the greater number of the beautiful and precious South Sea Islands are only the remnants of a vast continent or archipelago, which once stretched for thousands of miles between Australia and South America.

Now, applying the same theory to limestone beds, which are, as you know, only fossil coral reefs, we have a right to say, when we see in England, Scotland, Ireland, limestones several thousand feet thick, that while they were being laid down as coral reef, the sea-bottom, and probably the neighbouring land, must have been sinking to the amount of their thickness—to several thousand feet—before that later sinking which enabled several hundred feet of millstone grit to be laid down on the top of the limestone.

This millstone grit is a new and a very remarkable element in our strange story. From Derby to Northumberland it forms vast and lofty moors, capping, as at Whernside and Penygent, the highest limestone hills with its hard, rough, barren, and unfossiliferous strata. Wherever it is found, it lies on the top of the "mountain," or carboniferous limestone. Almost everywhere, where coal is found in England, it lies on the millstone grit. I speak roughly, for fear of confusing my readers with details. The three deposits pass more or less, in many places, into each other: but always in the order of mountain limestone below, millstone grit on it, and coal on that again.

Now what does its presence prove? What but this? That after the great coral reefs which spread over Somersetshire and South Wales, around the present estuary of the Severn,—and those, once perhaps joined to them, which spread from Derby to Berwick, with a western branch through North-east Wales,—

were laid down—after all this, I say, some change took place in the sea-bottom, and brought down on the reefs of coral sheets of sand, which killed the corals and buried them in grit. Does any reader wish for proof of this? Let him examine the "cherty," or flinty, beds which so often appear where the bottom of the millstone grit is passing into the top of the mountain limestone—the beds, to give an instance, which are now quarried on the top of the Halkin Mountain in Flintshire, for chert, which is sent to Staffordshire to be ground down for the manufacture of china. He will find layers in those beds, of several feet in thickness, as hard as flint, but as porous as sponge. On examining their cavities he will find them to be simply hollow casts of innumerable joints of Crinoids, so exquisitely preserved, even to their most delicate markings, that it is plain they were never washed about upon a beach, but have grown where, or nearly where, they lie. What then, has happened to them? They have been killed by the sand. The soft parts of the animals have decayed, letting the 140,000 joints (more or less) belonging to each animal fall into a heap, and be imbedded in the growing sand-rock; and then, it may be long years after, water filtering through the porous sand has removed the lime of which the joints were made, and left their perfect casts behind.

So much for the millstone grits. How long the deposition of sand went on, how long after it that second deposition of sands took place, which goes by the name of the "gannister," or lower coal-measures, we cannot tell. But it is clear, at least, that parts of that ancient sea were filling up and becoming dry

land. For coal, or fossilised vegetable matter, becomes more and more common as we ascend in the series of beds; till at last, in the upper coal-measures, the enormous wealth of vegetation which grew, much of it, where it is now found, prove the existence of some such sheets of fertile and forest-clad lowland as I described in my last paper.

Thousands of feet of rich coral reef; thousands of feet of barren sands; then thousands of feet of rich alluvial forest—and all these sliding into each other, if not in one place, then in another, without violent break or change; this is the story which the lime in the mortar and the coal on the fire, between the two, reveal.

VI.

THE SLATES ON THE ROOF.

THE slates on the roof should be, when rightly understood, a pleasant subject for contemplation to the dweller in a town. I do not ask him to imitate the boy who, cliff-bred from his youth, used to spend stolen hours on the house-top, with his back against a chimney-stalk, transfiguring in his imagination the roof-slopes into mountain-sides, the slates into sheets of rock, the cats into lions, and the sparrows into eagles. I only wish that he should—at least after reading this paper—let the slates on the roof carry him back in fancy to the mountains whence they came; perhaps to pleasant trips to the lakes and hills of Cumberland, Westmoreland, and North Wales; and to recognise—as he will do if he have intellect as well as fancy—how beautiful and how curious an object is a common slate.

Beautiful, not only for the compactness and delicacy of its texture, and for the regularity and smoothness of its surface, but still more for its colour. Whether merely warm grey, as when dry, or bright

purple, as when wet, the colour of the English slate well justifies Mr. Ruskin's saying, that wherever there is a brick wall and a slate roof there need be no want of rich colour in an English landscape. But most beautiful is the hue of slate, when, shining wet in the sunshine after a summer shower, its blue is brought out in rich contrast by golden spots of circular lichen, whose spores, I presume, have travelled with it off its native mountains. Then, indeed, it reminds the voyager of a sight which it almost rivals in brilliancy —of the sapphire of the deep ocean, brought out into blazing intensity by the contrast of the golden patches of floating gulf-weed beneath the tropic sun.

Beautiful, I say, is the slate; and curious likewise, nay, venerable; a most ancient and elaborate work of God, which has lasted long enough, and endured enough likewise, to bring out in it whatsoever latent capabilities of strength and usefulness might lie hid in it; which has literally been—as far as such words can apply to a thing inanimate—

> Heated hot with burning fears,
> And bathed in baths of hissing tears,
> And battered by the strokes of doom
> To shape and use.

And yet it was at first naught but an ugly lump of soft and shapeless ooze.

Therefore, the slates to me are as a parable, on which I will not enlarge, but will leave each reader to interpret it for himself. I shall confine myself now to proofs that slate is hardened mud, and to hints as to how it assumed its present form.

That slate may have been once mud, is made

probable by the simple fact that it can be turned into mud again. If you grind up slate, and then analyse it, you will find its mineral constituents to be exactly those of a fine, rich, and tenacious clay. The slate districts (at least in Snowdon) carry such a rich clay on them, wherever it is not masked by the ruins of other rocks. At Ilfracombe, in North Devon, the passage from slate below to clay above, may be clearly seen. Wherever the top of the slate beds, and the soil upon it, is laid bare, the black layers of slate may be seen gradually melting—if I may use the word—under the influence of rain and frost, into a rich tenacious clay, which is now not black, like its parent slate, but red, from the oxidation of the iron which it contains.

But, granting this, how did the first change take place?

It must be allowed, at starting, that time enough has elapsed, and events enough have happened, since our supposed mud began first to become slate, to allow of many and strange transformations. For these slates are found in the oldest beds of rocks, save one series, in the known world; and it is notorious that the older and lower the beds in which the slates are found, the better, that is, the more perfectly elaborate, is the slate. The best slates of Snowdon—I must confine myself to the district which I know personally—are found in the so-called "Cambrian" beds. Below these beds but one series of beds is as yet known in the world, called the "Laurentian." They occur, to a thickness of some eighty thousand feet, in Labrador, Canada, and the Adirondack mountains of New York: but their representatives in Europe are, as far as is

known, only to be found in the north-west highlands of Scotland, and in the island of Lewis, which consists entirely of them. And it is to be remembered, as a proof of their inconceivable antiquity, that they have been upheaved and shifted long before the Cambrian rocks were laid down "unconformably" on their worn and broken edges.

Above the "Cambrian" slates—whether the lower and older ones of Penrhyn and Llanberris, which are the same—one slate mountain being worked at both sides in two opposite valleys—or the upper and newer slates of Tremadoc, lie other and newer slate-bearing beds of inferior quality, and belonging to a yet newer world, the "Silurian." To them belong the Llandeilo flags and slates of Wales, and the Skiddaw slates of Cumberland, amid beds abounding in extinct fossil forms. Fossil shells are found, it is true, in the upper Cambrian beds. In the lower they have all but disappeared. Whether their traces have been obliterated by heat and pressure, and chemical action, during long ages; or whether, in these lower beds, we are actually reaching that "Primordial Zone" conceived of by M. Barrande, namely, rocks which existed before living things had begun to people this planet, is a question not yet answered. I believe the former theory to be the true one. That there was life, in the sea at least, even before the oldest Cambrian rocks were laid down, is proved by the discovery of the now famous fossil, the Eozoon, in the Laurentian limestones, which seems to have grown layer after layer, and to have formed reefs of limestone as do the living coral-building polypes. We know no more as yet. But all that we do know points downwards, downwards still, warning

us that we must dig deeper than we have dug as yet, before we reach the graves of the first living things.

Let this suffice at present for the Cambrian and Laurentian rocks.

The Silurian rocks, lower and upper, which in these islands have their chief development in Wales, and which are nearly thirty-eight thousand feet thick; and the Devonian or Old Red sandstone beds, which in the Fans of Brecon and Carmarthenshire attain a thickness of ten thousand feet, must be passed through in an upward direction before we reach the bottom of that Carboniferous Limestone of which I spoke in my last paper. We thus find on the Cambrian rocks forty-five thousand feet at least of newer rocks, in several cases lying unconformably on each other, showing thereby that the lower beds had been upheaved, and their edges worn off on a sea-shore, ere the upper were laid down on them; and throughout this vast thickness of rocks, the remains of hundreds of forms of animals, corals, shells, fish, older forms dying out in the newer rocks, and new ones taking their places, in a steady succession of ever-varying forms, till those in the upper beds have become unlike those in the lower, and all are from the beginning more or less unlike any existing now on earth. Whole families, indeed, disappear entirely, like the Trilobites, which seem to have swarmed in the Silurian seas, holding the same place there as crabs and shrimps do in our modern seas. They vanish after the period of the coal, and their place is taken by an allied family of Crustaceans, of which only one form (as far as I am aware) lingers now on earth, namely, the "King Crab," or Limulus, of the Indian Seas, a

well-known animal, of which specimens may sometimes be seen alive in English aquaria. So perished in the lapse of those same ages, the armour-plated or "Ganoid" fish which Hugh Miller made so justly famous—and which made him so justly famous in return—appearing first in the upper Silurian beds, and abounding in vast variety of strange forms in the old Red Sandstone, but gradually disappearing from the waters of the world, till their only representatives, as far as known, are the Lepidostei, or "Bony Pikes," of North America; the Polypteri of the Nile and Senegal; the Lepidosirens of the African lakes and Western rivers; the Ceratodus or Barramundi of Queensland (the two latter of which approach Amphibians), and one or two more fantastic forms, either rudimentary or degraded, which have lasted on here and there in isolated stations through long ages, comparatively unchanged while all the world is changed around them, and their own kindred, buried like the fossil Ceratodus of the Trias beneath thousands of feet of ancient rock, among creatures the likes whereof are not to be found now on earth. And these are but two examples out of hundreds of the vast changes which have taken place in the animal life of the globe, between the laying down of the Cambrian slates and the present time.

Surely—and it is to this conclusion I have been tending throughout a seemingly wandering paragraph—surely there has been time enough during all those ages for clay to change into slate.

And how were they changed?

I think I cannot teach my readers this more simply than by asking them first to buy Sheet No. LXXVIII.

S.E. (Bangor) of the Snowdon district of the Government Geological Survey, which may be ordered at any good stationer's, price 3*s.*; and study it with me. He will see down the right-hand margin interpretations of the different colours which mark the different beds, beginning with the youngest (alluvium) atop, and going down through Carboniferous Limestone and Sandstone, Upper Silurian, Lower Silurian, Cambrian, and below them certain rocks marked of different shades of red, which signify rocks either altered by heat, or poured out of old volcanic vents. He will next see that the map is covered with a labyrinth of red patches and curved lines, signifying the outcrop or appearance at the surface of these volcanic beds. They lie at every conceivable slope; and the hills and valleys have been scooped out by rain and ice into every conceivable slope likewise. Wherefore we see, here a broad patch of red, where the back of a sheet of Lava, Porphyry, Greenstone, or what not is exposed; there a narrow line curving often with the curve of the hill-side, where only the edge of a similar sheet is exposed; and every possible variety of shape and attitude between these two. He will see also large spaces covered with little coloured dots, which signify (as he will find at the margin) beds of volcanic ash. If he look below the little coloured squares on the margin, he will see figures marking the strike, or direction of the inclination of the beds—inclined, vertical, horizontal, contorted; that the white lines in the map signify faults, *i.e.* shifts in the strata; the gold lines, lodes of metal—the latter of which I should advise him strongly, in this district at least, not to meddle with: but to button up his pockets, and to put into

the fire, in wholesome fear of his own weakness and ignorance, any puffs of mining companies which may be sent him—as one or two have probably been sent him already.

Furnished with which keys to the map, let him begin to con it over, sure that there is if not an order, still a grand meaning in all its seeming confusion; and let him, if he be a courteous and grateful person, return due thanks to Professor Ramsay for having found it all out; not without wondering, as I have often wondered, how even Professor Ramsay's acuteness and industry could find it all out.

When my reader has studied awhile the confusion —for it is a true confusion—of the different beds, he will ask, or at least have a right to ask, what known process of nature can have produced it? How have these various volcanic rocks, which he sees marked as Felspathic Traps, Quartz Porphyries, Greenstones, and so forth, got intermingled with beds which he is told to believe are volcanic ashes, and those again with fossil-bearing Silurian beds and Cambrian slates, which he is told to believe were deposited under water? And his puzzle will not be lessened when he is told that, in some cases, as in that of the summit of Snowdon, these very volcanic ashes contain fossil shells.

The best answer I can give is to ask him to use his imagination, or his common sense; and to picture to himself what must go on in the case of a submarine eruption, such as broke out off the coast of Iceland in 1783 and 1830, off the Azores in 1811, and in our day in more than one spot in the Pacific Ocean.

A main bore or vent—or more than one—opens

itself between the bottom of the sea and the nether fires. From each rushes an enormous jet of high-pressure steam and other gases, which boils up through the sea, and forms a cloud above; that cloud descends again in heavy rain, and gives out often true lightning from its under side.

But it does more. It acts as a true steam-gun, hurling into the air fragments of cold rock rasped off from the sides of the bore, and fragments also of melted lava, and clouds of dust, which fall again into the sea, and form there beds either of fine mud or of breccia—that is, fragments of stone embedded in paste. This, the reader will understand, is no fancy sketch, as far as I am concerned. I have steamed into craters sawn through by the sea, and showing sections of beds of ash dipping outwards and under the sea, and in them boulders and pebbles of every size, which had been hurled out of the crater; and in them also veins of hardened lava, which had burrowed out through the soft ashes of the cone. Of those lava veins I will speak presently. What I want the reader to think of now is the immense quantity of ash which the steam-mitrailleuse hurls to so vast a height into the air, that it is often drifted many miles down to leeward. To give two instances: The jet of steam from Vesuvius, in the eruption of 1822, rose more than four miles into the air; the jet from the Souffrière of St. Vincent in the West Indies, in 1812, probably rose higher; certainly it met the N.E. trade-wind, for it poured down a layer of ashes, several inches thick, not only on St. Vincent itself, but on Barbadoes, eighty miles to windward, and therefore on all the sea between. Now let us consider what that represents—

a layer of fine mud, laid down at the bottom of the ocean, several inches thick, eighty miles at least long, and twenty miles perhaps broad, by a single eruption. Suppose that hardened in long ages (as it would be under pressure) into a bed of fine grained Felstone, or volcanic ash; and we can understand how the ash-beds of Snowdonia—which may be traced some of them for many square miles—were laid down at the bottom of an ancient sea.

But now about the lavas or true volcanic rocks, which are painted (as is usual in geological maps) red. Let us go down to the bottom of the sea, and build up our volcano towards the surface.

First, as I said, the subterranean steam would blast a bore. The dust and stones, rasped and blasted out of that hole would be spread about the sea-bottom as an ash-bed sloping away round the hole; then the molten lava would rise in the bore, and flow out over the ashes and the sea-bottom — perhaps in one direction, perhaps all round. Then, usually, the volcano, having vented itself, would be quieter for a time, till the heat accumulated below, and more ash was blasted out, making a second ash-bed; and then would follow a second lava flow. Thus are produced the alternate beds of lava and ash which are so common.

Now suppose that at this point the volcano was exhausted, and lay quiet for a few hundred years, or more. If there was any land near, from which mud and sand were washed down, we might have layers on layers of sediment deposited, with live shells, etc., living in them, which would be converted into fossils when they died; and so we should have fossiliferous

beds over the ashes and lavas. Indeed, shells might live and thrive in the ash-mud itself, when it cooled, and the sea grew quiet, as they have lived and thriven in Snowdonia.

Now suppose that after these sedimentary beds are laid down by water, the volcano breaks out again —what would happen?

Many things: specially this, which has often happened already.

The lava, kept down by the weight of these new rocks, searches for the point of least resistance, and finds it in a more horizontal direction. It burrows out through the softer ash-beds, and between the sedimentary beds, spreading itself along horizontally. This process accounts for the very puzzling, though very common case in Snowdon and elsewhere, in which we find lavas interstratified with rocks which are plainly older than those lavas. Perhaps when that is done the volcano has got rid of all its lava, and is quiet. But if not, sooner or later, it bores up through the new sedimentary rocks, faulting them by earthquake shocks till it gets free vent, and begins its layers of alternate ash and lava once more.

And consider this fact also: If near the first (as often happens) there is another volcano, the lava from one may run over the lava from the other, and we may have two lavas of different materials overlying each other, which have come from different directions. The ashes blown out of the two craters may mingle also, and so, in the course of ages, the result may be such a confusion of ashes, lavas, and sedimentary rocks as we find throughout most mountain ranges in Snowdon, in the Lake mountains, in the Auvergne in

France, in Sicily round Etna, in Italy round Vesuvius, and in so many West Indian Islands; the last confusion of which is very likely to be this:

That when the volcano has succeeded—as it did in the case of Sabrina Island off the Azores in 1811, and as it did, perhaps often, in Snowdonia—in piling up an ash cone some hundred feet out of the sea; that—as has happened to Sabrina Island—the cone is sunk again by earthquakes, and gnawn down at the same time by the sea-waves, till nothing is left but a shoal under water. But where have all its vast heaps of ashes gone? To be spread about over the bottom of the sea, to mingle with the mud already there, and so make beds of which, like many in Snowdon, we cannot say whether they are of volcanic or of marine origin, because they are of both.

But what has all this to do with the slates?

I shall not be surprised if my readers ask that question two or three times during this paper. But they must be kind enough to let me tell my story my own way. The slates were not made in a day, and I fear they cannot be explained in an hour: unless we begin carefully at the beginning in order to end at the end. Let me first make my readers clearly understand that all our slate-bearing mountains, and most also of the non-slate-bearing ones likewise, are formed after the fashion which I have described, namely, beneath the sea. I do not say that there may not have been, again, and again, ash-cones rising above the surface of the waves. But if so, they were washed away, again and again, ages before the land assumed anything of its present shape; ages before the beds were twisted and upheaved as they are now.

And therefore I beg my readers to put out of their minds once and for all the fancy that in any known part of these islands craters are to be still seen, such as exist in Etna, or Vesuvius, or other volcanoes now at work in the open air.

It is necessary to insist on this, because many people hearing that certain mountains are volcanic, conclude—and very naturally and harmlessly—that the circular lakes about their tops are true craters. I have been told, for instance, that that wonderful little blue Glas Llyn, under the highest cliff of Snowdon, is the old crater of the mountain; and I have heard people insist that a similar lake, of almost equal grandeur, in the south side of Cader Idris, is a crater likewise.

But the fact is not so. Any one acquainted with recent craters would see at once that Glas Llyn is not an ancient one; and I am not surprised to find the Government geologists declaring that the Llyn on Cader Idris is not one either. The fact is, that the crater, or rather the place where the crater has been, in ancient volcanoes of this kind, is probably now covered by one of the innumerable bosses of lava.

For, as an eruption ceases, the melted lava cools in the vents, and hardens; usually into lava infinitely harder than the ash-cone round it; and this, when the ash-cone is washed off, remains as the highest part of the hill, as in the Mont Dore and the Cantal in France, and in several extinct volcanoes in the Antilles. Of course the lava must have been poured out, and the ashes blown out from some vents or other, connected with the nether world of fire; probably from many successive vents. For in volcanoes, when one vent is choked, another is wont

to open at some fresh point of least resistance among the overlying rocks. But where are these vents? Buried deep under successive eruptions, shifted probably from their places by successive upheavings and dislocations; and if we wanted to find them we should have to quarry the mountain range all over, a mile deep, before we hit upon here and there a tap-root of ancient lava, connecting the upper and the nether worlds. There are such tap-roots, probably, under each of our British mountain ranges. But Snowdon, certainly, does not owe its shape to the fact of one of these old fire vents being under it. It owes its shape simply to the accident of some of the beds toward the summit being especially hard, and thus able to stand the wear and tear of sea-wave, ice, and rain. Its lakes have been formed quite regardless of the lie of the rocks, though not regardless of their relative hardness. But what forces scooped them out —whether they were originally holes left in the ground by earthquakes, and deepened since by rain and rivers, or whether they were scooped out by ice, or by any other means, is a question on which the best geologists are yet undecided—decided only on this—that craters they are not.

As for the enormous changes which have taken place in the outline of the whole of the mountains, since first their strata were laid down at the bottom of the sea: I shall give facts enough, before this paper is done, to enable readers to judge of them for themselves.

The reader will now ask, naturally enough, how such a heap of beds as I have described can take the shape of mountains like Snowdon.

Look at any sea cliff in which the strata are twisted and set on slope. There are hundreds of such in these isles. The beds must have been at one time straight and horizontal. But it is equally clear that they have been folded by being squeezed laterally. At least, that is the simplest explanation, as may be proved by experiment. Take a number of pieces of cloth, or any such stuff; lay them on each other and then squeeze them together at each end. They will arrange themselves in folds, just as the beds of the cliff have done. And if, instead of cloth, you take some more brittle matter, you will find that, as you squeeze on, these folds will tend to snap at the points of greatest tension or stretching, which will be of course at the anticlinal and synclinal lines—in plain English, the tops and bottoms of the folds. Thus cracks will be formed; and if the pressure goes on, the ends of the layers will shift against each other in the line of those cracks, forming faults like those so common in rocks.

But again, suppose that instead of squeezing these broken and folded lines together any more, you took off the pressure right and left, and pressed them upwards from below, by a mimic earthquake. They would rise; and as they rose leave open space between them. Now if you could contrive to squeeze into them from below a paste, which would harden in the cracks and between the layers, and so keep them permanently apart, you would make them into a fair likeness of an average mountain range—a mess—if I may make use of a plain old word—of rocks which have, by alternate contraction and expansion, helped in the latter case by the injection of molten lava, been thrust about as they are in most mountain ranges.

That such a contraction and expansion goes on in the crust of the earth is evident; for here are the palpable effects of it. And the simplest general cause which I can give for it is this: That things expand as they are heated, and contract as they are cooled.

Now I am not learned enough—and were I, I have not time—to enter into the various theories which philosophers have put forward, to account for these grand phenomena.

The most remarkable, perhaps, and the most probable, is the theory of M. Elie de Beaumont, which is, in a few words, this:

That this earth, like all the planets, must have been once in a state of intense heat throughout, as its mass inside is probably now.

That it must be cooling, and giving off its heat into space.

That, therefore, as it cools, its crust must contract.

That, therefore, in contracting, wrinkles (for the loftiest mountain chains are nothing but tiny wrinkles, compared with the whole mass of the earth), wrinkles, I say, must form on its surface from time to time. And that the mountain chains are these wrinkles.

Be that as it may, we may safely say this. That wherever the internal heat of the earth tends (as in the case of volcanoes) towards a particular spot, that spot must expand, and swell up, bulging the rocks out, and probably cracking them, and inserting melting lava into those cracks from below. On the other hand, if the internal heat leaves that spot again, and it cools, then it must contract more or less, in falling inward toward the centre of the earth; and so the beds must be crumpled, and crushed, and shifted

against each other still more, as those of our mountains have been.

But here may arise, in some of my readers' minds, a reasonable question—If these upheaved beds were once horizontal, should we not be likely to find them, in some places, horizontal still?

A reasonable question, and one which admits of a full answer.

They know, of course, that there has been a gradual, but steady, change in the animals of this planet; and that the relative age of beds can, on the strength of that known change, be determined generally by the fossils, usually shells, peculiar to them: so that if we find the same fashion of shells, and still more the same species of shells, in two beds in different quarters of the world, then we have a right to say—These beds were laid down at least about the same time. That is a general rule among all geologists, and not to be gainsaid.

Now I think I may say, that, granting that we can recognise a bed by its fossils, there are few or no beds which are found in one place upheaved, broken, and altered by heat, which are not found in some other place still horizontal, unbroken, unaltered, and more or less as they were at first.

From the most recent beds; from the upheaved coral-rocks of the West Indies, and the upheaved and faulted boulder clay and chalk of the Isle of Moen in Denmark—downwards through all the strata, down to that very ancient one in which the best slates are found, this rule, I believe, stands true.

It stands true, certainly, of the ancient Silurian rocks of Wales, Cumberland, Ireland, and Scotland.

For, throughout great tracts of Russia, and in parts of Norway and Sweden, Sir Roderick Murchison discovered our own Silurian beds, recognisable from their peculiar fossils. But in what state? Not contracted, upheaved, and hardened to slates and grits, as they are in Wales and elsewhere: but horizontal, unbroken, and still soft, because undisturbed by volcanic rocks and earthquakes. At the bottom of them all, near Petersburg, Sir Roderick found a shale of dried mud (to quote his own words), "so soft and incoherent that it is even used by sculptors for modelling, although it underlies the great mass of fossil-bearing Silurian rocks, and is, therefore, of the same age as the lower crystalline hard slates of North Wales. So entirely have most of these eldest rocks in Russia been exempted from the influence of change, throughout those enormous periods which have passed away since their accumulation."

Among the many discoveries which science owes to that illustrious veteran, I know none more valuable for its bearing on the whole question of the making of the earth-crust, than this one magnificent fact.

But what a contrast between these Scandinavian and Russian rocks and those of Britain! Never exceeding, in Scandinavia, a thousand feet in thickness, and lying usually horizontal, as they were first laid down, they are swelled in Britain to a thickness of thirty thousand feet, by intruded lavas and ashes; snapt, turned, set on end at every conceivable angle; shifted against each other to such an extent, that, to give a single instance, in the Vale of Gwynnant, under Snowdon, an immense wedge of porphyry has been thrust up, in what is now the bottom of the valley,

between rocks far newer than it, on one side to a height of eight hundred, on the other to a height of eighteen hundred feet—half the present height of Snowdon. Nay, the very slate beds of Snowdonia have not forced their way up from under the mountain without long and fearful struggles. They are set in places upright on end, then horizontal again, then sunk in an opposite direction, then curled like sea-waves, then set nearly upright once more, and faulted through and through, six times, I believe, in the distance of a mile or two; they carry here and there on their backs patches of newer beds, the rest of which has long vanished; and in their rise they have hurled back to the eastward, and set upright, what is now the whole western flank of Snowdon, a mass of rock which was then several times as thick as it is now.

The force which thus tortured them was probably exerted by the great mass of volcanic Quartz-porphyry, which rises from under them to the north-west, crossing the end of the lower lake of the Llanberris; and indeed the shifts and convulsions which have taken place between them and the Menai Straits are so vast that they can only be estimated by looking at them on the section which may be found at the end of Professor Ramsay's "Geological Survey of North Wales." But anyone who will study that section, and use (as with the map) a little imagination and common sense, will see that between the heat of that Porphyry, which must have been poured out as a fluid mass as hot, probably, as melted iron, and the pressure of it below, and of the Silurian beds above, the Cambrian mud-strata of Llanberris and Penrhyn quarries must have

suffered enough to change them into something very different from mud, and, therefore, probably, into what they are now—namely, slate.

And now, at last, we have got to the slates on the roof, and may disport ourselves over them—like the cats.

Look at any piece of slate. All know that slate splits or cleaves freely, in one direction only, into flat layers. Now any one would suppose at first sight, and fairly enough, that the flat surface—the "plane of cleavage"—was also the plane of bedding. In simpler English we should say—The mud which has hardened into the slate was laid down horizontally; and therefore each slate is one of the little horizontal beds of it, perhaps just what was laid down in a single tide. We should have a right to do so, because that would be true of most sedimentary rocks. But it would not be true of slate. The plane of bedding in slate has nothing to do with the plane of cleavage. Or, more plainly, the mud of which the slate is made may have been deposited at the sea-bottom at any angle to the plane of cleavage. We may sometimes see the lines of the true bedding—the lines which were actually horizontal when the mud was laid down—in bits of slate, and find them sometimes perpendicular to, sometimes inclined to, and sometimes again coinciding with the plane of cleavage, which they have evidently acquired long after.

Nay, more. These parallel planes of cleavage, at each of which the slate splits freely, will run through a whole mountain at the same angle, though the beds through which they run may be tilted at different angles, and twisted into curves.

Now what has made this change in the rock? We do not exactly know. One thing is clear, that the particles of the now solid rock have actually moved on themselves. And this is proved by a very curious fact—which the reader, if he geologises about slate quarries much, may see with his own eyes. The fossils in the slate are often distorted into quaint shapes, pulled out long if they lie along the plane of cleavage, or squeezed together, or doubled down on both sides, if they lie across the plane. So that some force has been at work which could actually change the shape of hard shells, very slowly, no doubt, else it would have snapped and crumbled them.

If I am asked what that force was, I do not know. I should advise young geologists to read what Sir Henry de la Bêche has said on it in his admirable "Geological Observer," pp. 706–725. He will find there, too, some remarks on that equally mysterious phenomena of jointing, which you may see in almost all the older rocks; it is common in limestones. All we can say is, that some force has gone on, or may be even now going on, in the more ancient rocks, which is similar to that which produces single crystals; and similar, too, to that which produced the jointed crystals of basalt, *i.e.* lava, at the Giant's Causeway, in Ireland, and Staffa, in the Hebrides. Two philosophers—Mr. Robert Were Fox and Mr. Robert Hunt—are of opinion that the force which has determined the cleavage of slates may be that of the electric currents, which (as is well known) run through the crust of the earth. Mr. Sharpe, I believe, attributes the cleavage to the mere mechanical pressure of enormous weights of rock, especially where crushed by earthquakes. Professor

Rogers, again, points out that as these slates may have been highly heated, thermal electricity (*i.e.* electricity brought out by heat) may have acted on them.

One thing at least is clear. That the best slates are found among ancient lavas, and also in rocks which are faulted and tilted enormously, all which could not have happened without a proportionately enormous pressure, and therefore heat; and next, that the best slates are invariably found in the oldest beds—that is, in the beds which have had most time to endure the changes, whether mechanical or chemical, which have made the earth's surface what we see it now.

Another startling fact the section of Snowdonia, and I believe of most mountain chains in these islands, would prove—namely, that the contour of the earth's surface, as we see it now, depends very little, certainly in mountains composed of these elder rocks upon the lie of the strata, or beds, but has been carved out by great forces, long after those beds were not only laid down and hardened, but faulted and tilted on end. Snowdon itself is so remarkable an instance of this fact that, as it is a mountain which every one in these happy days of excursion-trains and steamers either has seen or can see, I must say a few more words about it.

Any one who saw that noble peak leaping high into the air, dominating all the country round, at least upon three sides, and was told that its summit consisted of beds much newer, not much older, than the slate-beds fifteen hundred feet down on its north-western flank—any one, I say, would have the right at first sight, on hearing of earthquake faults and upheavals, to say—The peak of Snowdon has been

upheaved to its present height above and out of the lower lands around. But when he came to examine sections, he would find his reasonable guess utterly wrong. Snowdon is no swelling up of the earth's crust. The beds do not, as they would in that case, slope up to it. They slope up from it, to the north-west in one direction, and the south-south-west in the other; and Snowdon is a mere insignificant boss, left hanging on one slope of what was once an enormous trough, or valley, of strata far older than itself. By restoring these strata, in the direction of the angles, in which they crop out, and vanish at the surface, it is found that to the north-west—the direction of the Menai Straits—they must once have risen to a height of at least six or seven thousand feet; and more, by restoring them, specially the ash-bed of Snowdon, towards the south-east—which can be done by the guidance of certain patches of it left on other hills—it is found that south of Ffestiniog, where the Cambrian rocks rise again to the surface, the south side of the trough must have sloped upwards to a height of from fifteen to twenty thousand feet, whether at the bottom of the sea, or in the upper air, we cannot tell. But the fact is certain, that off the surface of Wales, south of Ffestiniog a mass of solid rock as high as the Andes has been worn down and carried bodily away; and that a few miles south again, the peak of Arran Mowddy, which is now not two thousand feet high, was once—either under the sea or above it—nearer ten thousand feet.

If I am asked whither is all that enormous mass of rock—millions of tons—gone? Where is it now? I know not. But if I dared to hazard a guess, I

should say it went to make the New Red sandstones of England.

The New Red sandstones must have come from somewhere. The most likely region for them to have come from is from North Wales, where, as we know, vast masses of gritty rock have been ground off, such as would make fine sandstones if they had the chance. So that many a grain of sand in Chester walls was probably once blasted out of the bowels of the earth into the old Silurian sea, and after a few hundreds of thousands of years' repose in a Snowdonian ash-bed, was sent eastward to build the good old city and many a good town more.

And the red marl—the great deposit of red marl which covers a wide region of England—why should not it have come from the same quarter? Why should it not be simply the remains of the Snowdon Slate? Mud the slate was, and into mud it has returned. Why not? Some of the richest red marl land I know, is, as I have said, actually being made now, out of the black slates of Ilfracombe, wherever they are weathered by rain and air. The chemical composition is the same. The difference in colour between black slate and red marl is caused simply by the oxidation of the iron in the slate.

And if my readers want a probable cause why the sandstones lie undermost, and the red marl uppermost —can they not find one for themselves? I do not say that it is the cause, but it is at least a causa vera, one which would fully explain the fact, though it may be explicable in other ways. Think, then, or shall I think for my readers?

Then do they not see that when the Welsh

mountains were ground down, the Silurian strata, being uppermost, would be ground down first, and would go to make the lower strata of the great New Red Sandstone Lowland; and that being sandy, they would make the sandstones? But wherever they were ground through, the Lower Cambrian slates would be laid bare; and their remains, being washed away by the sea the last, would be washed on to the top of the remains of the Silurians; and so (as in most cases) the remains of the older rock, when redeposited by water, would lie on the remains of the younger rock. And do they not see that (if what I just said is true) these slates would grind up into red marl, such as is seen over the west and south of Cheshire and Staffordshire and far away into Nottinghamshire? The red marl must almost certainly have been black slate somewhere, somewhen. Why should it not have been such in Snowdon? And why should not the slates in the roof be the remnants of the very beds which are now the marl in the fields?

And thus I end my story of the slates in the roof, and these papers on Town Geology. I do so, well knowing how imperfect they are: though not, I believe, inaccurate. They are, after all, merely suggestive of the great amount that there is to be learnt about the face of the earth and how it got made, even by the townsman, who can escape into the country and exchange the world of man for the world of God, only, perhaps, on Sundays—if, alas! even then—or only once a year by a trip in a steamer or an excursion train. Little, indeed, can he learn of the planet on which he lives. Little in that direction is given to him, and of him little shall be required. But to him,

for that very reason, all that can be given should be given; he should have every facility for learning what he can about this earth, its composition, its capabilities; lest his intellect, crushed and fettered by that artificial drudgery which we for a time miscall civilisation, should begin to fancy, as too many do already, that the world is composed mainly of bricks and deal, and governed by acts of parliament. If I shall have awakened any townsmen here and there to think seriously of the complexity, the antiquity, the grandeur, the true poetry, of the commonest objects around them, even the stones beneath their feet; if I shall have suggested to them the solemn thought that all these things, and they themselves still more, are ordered by laws, utterly independent of man's will about them, man's belief in them; if I shall at all have helped to open their eyes that they may see, and their ears that they may hear, the great book which is free to all alike, to peasant as to peer, to men of business as to men of science, even that great book of nature, which is, as Lord Bacon said of old, the Word of God revealed in facts—then I shall have a fresh reason for loving that science of geology, which has been my favourite study since I was a boy.

ON BIO-GEOLOGY.

ON BIO-GEOLOGY.*

I AM not sure that the subject of my address is rightly chosen. I am not sure that I ought not to have postponed a question of mere natural history, to speak to you as scientific men, on the questions of life and death, which have been forced upon us by the awful warning of an illustrious personage's illness; of preventible disease, its frightful prevalency; of the 200,000 persons who are said to have died of fever alone since the Prince Consort's death, ten years ago; of the remedies; of drainage; of sewage disinfection and utilisation; and of the assistance which you, as a body of scientific men, can give to any effort towards saving the lives and health of our fellow-citizens from those unseen poisons which lurk like wild beasts couched in the jungle, ready to spring at any moment on the unsuspecting, the innocent, the helpless. Of all this I longed to speak; but I thought it best only to hint at it, and leave the question to your common sense and your humanity; taking for granted that your minds, like the minds of all right-minded English-

* An Address given to the Scientific Society of Winchester, 1871.

men, have been of late painfully awakened to its importance. It seemed to me almost an impertinence to say more in a city of whose local circumstances I know little or nothing. As an old sanitary reformer, practical, as well as theoretical, I am but too well aware of the difficulties which beset any complete scheme of drainage, especially in an ancient city like this; where men are paying the penalty of their predecessors' ignorance; and dwelling, whether they choose or not, over fifteen centuries of accumulated dirt.

And, therefore, taking for granted that there is energy and intellect enough in Winchester to conquer these difficulties in due time, I go on to ask you to consider, for a time, a subject which is growing more and more important and interesting, a subject the study of which will do much towards raising the field naturalist from a mere collector of specimens—as he was twenty years ago—to a philosopher elucidating some of the grandest problems. I mean the infant science of Bio-geology—the science which treats of the distribution of plants and animals over the globe, and the cause of that distribution.

I doubt not that there are many here who know far more about the subject than I; who are far better read than I am in the works of Forbes, Darwin, Wallace, Hooker, Moritz Wagner, and the other illustrious men who have written on it. But I may, perhaps, give a few hints which will be of use to the younger members of this Society, and will point out to them how to get a new relish for the pursuit of field science.

Bio-geology, then, begins with asking every plant or animal you meet, large or small, not merely—What is your name? That is the collector and classifier's

duty; and a most necessary duty it is, and one to be performed with the most conscientious patience and accuracy, so that a sound foundation may be built for future speculations. But young naturalists should act not merely as Nature's registrars and census-takers, but as her policemen and gamekeepers; and ask everything they meet—How did you get there? By what road did you come? What was your last place of abode? And now you are here, how do you get your living? Are you and your children thriving, like decent people who can take care of themselves, or growing pauperised and degraded, and dying out? Not that we have a fear of your becoming a dangerous class. Madame Nature allows no dangerous classes, in the modern sense. She has, doubtless for some wise reason, no mercy for the weak. She rewards each organism according to its works; and if anything grows too weak or stupid to take care of itself, she gives it its due deserts by letting it die and disappear. So, you plant or you animal, are you among the strong, the successful, the multiplying, the colonising? Or are you among the weak, the failing, the dwindling, the doomed?

These questions may seem somewhat rude: but you may comfort yourself by the thought that plants and animals, though they deserve all kindness, all admiration, deserve no courtesy—at least in this respect. For they are, one and all, wherever you find them, vagrants and landlopers, intruders and conquerors, who have got where they happen to be simply by the law of the strongest—generally not without a little robbery and murder. They have no right save that of possession; the same by which the

puffin turns out the old rabbits, eats the young ones, and then lays her eggs in the rabbit-burrow—simply because she can.

Now, you will see at once that such a course of questioning will call out a great many curious and interesting answers, if you can only get the things to tell you their story; as you always may if you will cross-examine them long enough; and will lead you into many subjects beside mere botany or entomology. So various, indeed, are the subjects which you will thus start, that I can only hint at them now in the most cursory fashion.

At the outset you will soon find yourself involved in chemical and meteorological questions; as, for instance, when you ask—How is it that I find one flora on the sea-shore, another on the sandstone, another on the chalk, and another on the peat-making gravelly strata? The usual answer would be, I presume—if we could work it out by twenty years' experiment, such as Mr. Lawes, of Rothampsted, has been making on the growth of grasses and leguminous plants in different soils and under different manures—the usual answer, I say, would be—Because we plants want such and such mineral constituents in our woody fibre; again, because we want a certain amount of moisture at a certain period of the year: or, perhaps, simply because the mechanical arrangement of the particles of a certain soil happens to suit the shape of our roots and of their stomata. Sometimes you will get an answer quickly enough; sometimes not. If you ask, for instance, *Asplenium viride* how it contrives to grow plentifully in the Craven of Yorkshire down to 600 or 800 feet above the sea, while in Snowdon it dislikes growing

lower than 2000 feet, and is not plentiful even there?—it will reply—Because in the Craven I can get as much carbonic acid as I want from the decomposing limestone; while on the Snowdon Silurian I get very little; and I have to make it up by clinging to the mountain tops, for the sake of the greater rainfall. But if you ask *Polypodium calcareum*—How is it you choose only to grow on limestone, while *Polypodium Dryopteris*, of which, I suspect, you are only a variety, is ready to grow anywhere?—*Polypodium calcareum* will refuse, as yet, to answer a word.

Again—I can only give you the merest string of hints—you will find in your questionings that many plants and animals have no reason at all to show why they should be in one place and not in another, save the very sound reason for the latter which was suggested to me once by a great naturalist. I was asking—Why don't I find such and such a species in my parish, while it is plentiful a few miles off in exactly the same soil?—and he answered—For the same reason that you are not in America. Because you have not got there. Which answer threw to me a flood of light on this whole science. Things are often where they are, simply because they happen to have got there, and not elsewhere. But they must have got there by some means, and those means I want young naturalists to discover; at least, to guess at.

A species, for instance—and I suspect it is a common case with insects—may abound in a single spot, simply because, long years ago, a single brood of eggs happened to hatch at a time when eggs of other species, who would have competed against them for food, did not hatch; and they may remain confined to that spot,

though there is plenty of food for them outside it, simply because they do not increase fast enough to require to spread out in search of more food. Thus I should explain a case which I heard of lately of *Anthocera trifolii*, abundant for years in one corner of a certain field, and only there; while there was just as much trefoil all round for its larvæ as there was in the selected spot. I can, I say, only give hints: but they will suffice, I hope, to show the path of thought into which I want young naturalists to turn their minds.

Or, again, you will have to inquire whether the species has not been prevented from spreading by some natural barrier. Mr. Wallace, whom you all of course know, has shown in his "Malay Archipelago" that a strait of deep sea can act as such a barrier between species. Moritz Wagner has shown that, in the case of insects, a moderately-broad river may divide two closely-allied species of beetles, or a very narrow snow-range, two closely-allied species of moths.

Again, another cause, and a most common one, is: that the plants cannot spread because they find the ground beyond them already occupied by other plants, who will not tolerate a fresh mouth, having only just enough to feed themselves. Take the case of *Saxifraga hypnoides* and *S. umbrosa*, "London pride." They are two especially strong species. They show that, *S. hypnoides* especially, by their power of sporting, of diverging into varieties; they show it equally by their power of thriving anywhere, if they can only get there. They will grow both in my sandy garden, under a rainfall of only 23 inches, more luxuriantly than in their native mountains under a rainfall of 50 or 60 inches. Then how is it that *S. hypnoides* cannot get

down off the mountains; and that *S. umbrosa*, though in Kerry it has got off the mountains and down to the sea-level, exterminating, I suspect, many species in its progress, yet cannot get across County Cork? The only answer is, I believe, that both species are continually trying to go ahead; but that the other plants already in front of them are too strong for them, and massacre their infants as soon as born.

And this brings us to another curious question: the sudden and abundant appearance of plants, like the foxglove and *Epilobium angustifolium*, in spots where they have never been seen before. Are there seeds, as some think, dormant in the ground; or are the seeds which have germinated, fresh ones wafted thither by wind or otherwise, and only able to germinate in that one spot because there the soil is clear? General Monro, now famous for his unequalled memoir on the bamboos, holds to the latter theory. He pointed out to me that the *Epilobium* seeds, being feathered, could travel with the wind; that the plant always made its appearance first on new banks, landslips, clearings, where it had nothing to compete against; and that the foxglove did the same. True, and most painfully true, in the case of thistles and groundsels: but foxglove seeds, though minute, would hardly be carried by the wind any more than those of the white clover, which comes up so abundantly in drained fens. Adhuc sub judice lis est, and I wish some young naturalists would work carefully at the solution; by experiment, which is the most sure way to find out anything.

But in researches in this direction they will find puzzles enough. I will give them one which I shall

be most thankful to hear they have solved within the next seven years—How is it that we find certain plants, namely, the thrift and the scurvy grass, abundant on the sea-shore and common on certain mountain-tops, but nowhere between the two? Answer me that. For I have looked at the fact for years—before, behind, sideways, upside down, and inside out—and I cannot understand it.

But all these questions, and especially, I suspect, that last one, ought to lead the young student up to the great and complex question—How were these islands re-peopled with plants and animals, after the long and wholesale catastrophe of the glacial epoch?

I presume you all know, and will agree, that the whole of these islands, north of the Thames, save certain ice-clad mountain-tops, were buried for long ages under an icy sea. From whence did vegetable and animal life crawl back to the land, as it rose again; and cover its mantle of glacial drift with fresh life and verdure?

Now let me give you a few prolegomena on this matter. You must study the plants of course, species by species. Take Watson's "Cybele Britannica" and Moore's "Cybele Hibernica;" and let—as Mr. Matthew Arnold would say—"your thought play freely about them." Look carefully, too, in the case of each species, at the note on its distribution, which you will find appended in Bentham's "Handbook," and in Hooker's "Student's Flora." Get all the help you can, if you wish to work the subject out, from foreign botanists, both European and American; and I think that, on the whole, you will come to some such theory as this for a general starting platform. We do not owe our

flora—I must keep to the flora just now—to so many different regions, or types, as Mr. Watson conceives, but to three, namely, an European or Germanic flora, from the south-east; an Atlantic flora, from the south-east; a Northern flora, from the north. These three invaded us after the glacial epoch; and our general flora is their result.

But this will cause you much trouble. Before you go a step farther you will have to eliminate from all your calculations most of the plants which Watson calls glareal, *i.e.* found in cultivated ground about habitations. And what their limit may be I think we never shall know. But of this we may be sure; that just as invading armies always bring with them, in forage or otherwise, some plants from their own country—just as the Cossacks, in 1815, brought more than one Russian plant through Germany into France—just as you have already a crop of North German plants upon the battle-fields of France—thus do conquering races bring new plants. The Romans, during their 300 or 400 years of occupation and civilisation, must have brought more species, I believe, than I dare mention. I suspect them of having brought, not merely the common hedge elm of the south, not merely the three species of nettle, but all our red poppies, and a great number of the weeds which are common in our cornfields; and when we add to them the plants which may have been brought by returning crusaders and pilgrims; by monks from every part of Europe, by Flemings or other dealers in foreign wool—we have to cut a huge cantle out of our indigenous flora: only, having no records, we hardly know where and what to cut out; and can only, we elder ones, recommend the subject to the notice of the

younger botanists, that they may work it out after our work is done.

Of course these plants introduced by man, if they are cut out, must be cut out of only one of the floras, namely, the European; for they, probably, came from the south-east, by whatever means they came.

That European flora invaded us, I presume, immediately after the glacial epoch, at a time when France and England were united, and the German Ocean a mere network of rivers, which emptied into the deep sea between Scotland and Scandinavia. And here I must add, that endless questions of interest will arise to those who will study, not merely the invasion of that truly European flora, but the invasion of reptiles, insects, and birds, especially birds of passage, which must have followed it as soon as the land was sufficiently covered with vegetation to support life. Whole volumes remain to be written on this subject. I trust that some of your younger members may live to write one of them. The way to begin will be: to compare the flora and fauna of this part of England very carefully with that of the southern and eastern counties; and then to compare them again with the fauna and flora of France, Belgium, and Holland.

As for the Atlantic flora, you will have to decide for yourselves whether you accept or not the theory of a sunken Atlantic continent. I confess that all objections to that theory, however astounding it may seem, are outweighed in my mind by a host of facts which I can explain by no other theory. But you must judge for yourselves; and to do so you must study carefully the distribution of heaths both in Europe and at the Cape, and their non-appearance

beyond the Ural Mountains, and in America, save in Labrador, where the common ling, an older and less specialised form, exists. You must consider, too, the plants common to the Azores, Portugal, the West of England, Ireland, and the Western Hebrides. In so doing young naturalists will at least find proofs of a change in the distribution of land and water, which will utterly astound them when they face it for the first time.

As for the Northern flora, the question whence it came is puzzling enough. It seems difficult to conceive how any plants could have survived when Scotland was an archipelago in the same ice-covered condition as Greenland is now; and we have no proof that there existed after the glacial epoch any northern continent from which the plants and animals could have come back to us. The species of plants and animals common to Britain, Scandinavia, and North America, must have spread in pre-glacial times when a continent joining them did exist.

But some light has been thrown on this question by an article, as charming as it is able, on "The Physics of the Arctic Ice," by Dr. Brown of Campster. You will find it in the "Quarterly Journal of the Geological Society" for February, 1870. He shows there that even in Greenland peaks and crags are left free enough from ice to support a vegetation of between three hundred or four hundred species of flowering plants; and, therefore, he well says, we must be careful to avoid concluding that the plant and animal life on the dreary shores or mountain-tops of the old glacial Scotland was poor. The same would hold good of our mountains; and, if so, we may look with respect, even

awe, on the Alpine plants of Wales, Scotland, and the Lake mountains, as organisms, stunted it may be, and even degraded by their long battle with the elements, but venerable from their age, historic from their endurance. Relics of an older temperate world, they have lived through thousands of centuries of frost and fog, to sun themselves in a temperate climate once more. I can never pick one of them without a tinge of shame; and to exterminate one of them is to destroy, for the mere pleasure of collecting, the last of a family which God has taken the trouble to preserve for thousands of centuries.

I trust that these hints—for I can call them nothing more—will at least awaken any young naturalist who has hitherto only collected natural objects, to study the really important and interesting question—How did these things get here?

Now hence arise questions which may puzzle the mind of a Hampshire naturalist. You have in this neighbourhood, as you well know, two, or rather three, soils, each carrying its peculiar vegetation. First, you have the clay lying on the chalk, and carrying vast woodlands, seemingly primeval. Next, you have the chalk, with its peculiar, delicate, and often fragrant crop of lime-loving plants; and next, you have the poor sands and clays of the New Forest basin, saturated with iron, and therefore carrying a moorland or peat-loving vegetation, in many respects quite different from the others. And this moorland soil, and this vegetation, with a few singular exceptions, repeats itself, as I daresay you know, in the north of the county, in the Bagshot basin, as it is called—the moors of Aldershot, Hartford Bridge, and Windsor Forest.

Now what a variety of interesting questions are opened up by these simple facts. How did these three floras get each to its present place? Where did each come from? How did it get past or through the other, till each set of plants, after long internecine competition, settled itself down in the sheet of land most congenial to it? And when did each come hither? Which is the oldest? Will any one tell me whether the healthy floras of the moors, or the thymy flora of the chalk downs, were the earlier inhabitants of these isles? To these questions I cannot get any answer; and they cannot be answered without, first—a very careful study of the range of each species of plant on the continent of Europe; and next, without careful study of those stupendous changes in the shape of this island which have taken place at a very late geological epoch. The composition of the flora of our moorlands is as yet to me an utter puzzle. We have Lycopodiums—three species—enormously ancient forms which have survived the age of ice: but did they crawl downward hither from the northern mountains or upward hither from the Pyrenees? We have the beautiful bog asphodel again—an enormously ancient form; for it is, strange to say, common to North America and to Northern Europe, but does not enter Asia—almost an unique instance. It must, surely, have come from the north; and points—as do many species of plants and animals—to the time when North Europe and North America were joined. We have, sparingly, in North Hampshire, though, strangely, not on the Bagshot moors, the Common or Northern Butterwort (*Pinguicula vulgaris*); and also, in the south, the New Forest part of the county, the delicate little *Pinguicula lusitanica*, the

only species now found in Devon and Cornwall, marking the New Forest as the extreme eastern limit of the Atlantic flora. We have again the heaths, which, as I have just said, are found neither in America nor in Asia, and must, I believe, have come from some south-western land long since submerged beneath the sea. But more, we have in the New Forest two plants which are members of the South Europe, or properly, the Atlantic flora; which must have come from the south and south-east; and which are found in no other spots in these islands. I mean the lovely *Gladiolus*, which grows abundantly under the ferns near Lyndhurst, certainly wild, but it does not approach England elsewhere nearer than the Loire and the Rhine; and next, that delicate orchid, the *Spiranthes æstivalis*, which is known only in a bog near Lyndhurst and in the Channel Islands, while on the Continent it extends from Southern Europe all through France. Now, what do these two plants mark? They give us a point in botany, though not in time, to determine when the south of England was parted from the opposite shores of France; and whenever that was, it was just after the Gladiolus and Spiranthes got hither. Two little colonies of these lovely flowers arrived just before their retreat was cut off. They found the country already occupied with other plants; and, not being reinforced by fresh colonists from the south, have not been able to spread farther north than Lyndhurst. Thus, in the New Forest, and, I may say in the Bagshot moors, you find plants which you do not expect, and do not find plants which you do expect; and you are, or ought to be, puzzled, and I hope also interested, and stirred up to find out more.

I spoke just now of the time when England was joined to France, as bearing on Hampshire botany. It bears no less on Hampshire zoology. In insects, for instance, the presence of the purple emperor and the white admiral in our Hampshire woods, as well as the abundance of the great stag-beetle, point to a time when the two countries were joined, at least as far west as Hampshire; while the absence of these insects farther to the westward shows that the countries, if ever joined, were already parted; and that those insects have not yet had time to spread westward. The presence of these two butterflies, and partly of the stag-beetle, along the south-east coast of England as far as the primeval forests of South Lincolnshire, points, as do a hundred other facts, to a time when the Straits of Dover either did not exist, or were the bed of a river running from the west; and when, as I told you just now, all the rivers which now run into the German Ocean, from the Humber on the west to the Elbe on the east, discharged themselves into the sea between Scotland and Norway, after wandering through a vast lowland, covered with countless herds of mammoth, rhinoceros, gigantic ox, and other mammals now extinct; while the birds, as far as we know, the insects, the fresh-water fish, and even, as my friend Mr. Brady has proved, the *Entomostraca* of the rivers, were the same in what is now Holland as in what is now our Eastern counties. I could dwell long on this matter. I could talk long about how certain species of *Lepidoptera*—moths and butterflies—like *Papilio Machaon* and *P. Podalirius*, swarm through France, reach up to the British Channel, and have not crossed it, with the exception of one colony

of *Machaon* in the Cambridgeshire fens. I could talk long about a similar phenomenon in the case of our migratory and singing birds; how many exquisite species—notably those two glorious songsters, the Orphean Warbler and Hippolais, which delight our ears everywhere on the other side of the Channel—follow our nightingales, blackcaps, and warblers northward every spring almost to the Straits of Dover, but dare not cross, simply because they have been, as it were, created since the gulf was opened, and have never learnt from their parents how to fly over it.

In the case of fishes, again, I might say much on the curious fact that the Cyprinidæ, or white fish—carp, etc.—and their natural enemy, the pike, are indigenous, I believe, only to the rivers, English or continental, on the eastern side of the Straits of Dover; while the rivers on the western side were originally tenanted, like our Hampshire streams, as now, almost entirely by trout, their only Cyprinoid being the minnow—if it, too, be not an interloper; and I might ask you to consider the bearing of this curious fact on the former junction of England and France.

But I have only time to point out to you a few curious facts with regard to reptiles, which should be specially interesting to a Hampshire bio-geologist. You know, of course, that in Ireland there are no reptiles, save the little common lizard, *Lacerta agilis*, and a few frogs on the mountain-tops—how they got there I cannot conceive. And you will, of course, guess, and rightly, that the reason of the absence of reptiles is: that Ireland was parted off from England

before the creatures, which certainly spread from southern and warmer climates, had time to get there. You know, of course, that we have a few reptiles in England. But you may not be aware that, as soon as you cross the Channel, you find many more species of reptiles than here, as well as those which you find here. The magnificent green lizard which rattles about like a rabbit in a French forest, is never found here; simply because it had not worked northward till after the Channel was formed. But there are three reptiles peculiar to this part of England which should be most interesting to a Hampshire zoologist. The one is the sand lizard (*L. stirpium*), found on Bourne-heath, and, I suspect, in the South Hampshire moors likewise—a North European and French species. Another, the *Coronella lævis*, a harmless French and Austrian snake, which has been found about me, in North Hants and South Berks, now about fifteen or twenty times. I have had three specimens from my own parish. I believe it not to be uncommon; and most probably to be found, by those who will look, both in the New Forest and Woolmer. The third is the Natterjack, or running toad (*Bufo Rubeta*), a most beautifully-spotted animal, with a yellow stripe down his back, which is common with us at Eversley, and common also in many moorlands of Hants and Surrey; and, according to Fleming, on heaths near London, and as far north-east as Lincolnshire; in which case it will belong to the Germanic fauna. Now, here again we have cases of animals which have just been able to get hither before the severance of England and France; and which, not being reinforced from the rear, have been forced to stop, in small and probably decreasing

colonies, on the spots nearest the coast which were fit for them.

I trust that I have not kept you too long over these details. What I wish to impress upon you is that Hampshire is a country specially fitted for the study of important bio-geological questions.

To work them out, you must trace the geology of Hampshire, and indeed, of East Dorset. You must try to form a conception of how the land was shaped in miocene times, before that tremendous upheaval which reared the chalk cliffs at Freshwater upright, lifting the tertiary beds upon their northern slopes. You must ask—Was there not land to the south of the Isle of Wight in those ages, and for ages after; and what was its extent and shape? You must ask—When was the gap between the Isle of Wight and the Isle of Purbeck sawn through, leaving the Needles as remnants on one side, and Old Harry on the opposite? And was it sawn asunder merely by the age-long gnawing of the waves? You must ask—Where did the great river which ran from the west, where Poole Harbour is now, and probably through what is now the Solent, depositing brackish water-beds right and left—where, I say, did it run into the sea? Where the Straits of Dover are now? Or, if not there, where? What, too, is become of the land to the Westward, composed of ancient metamorphic rocks, out of which it ran, and deposited on what are now the Haggerstone Moors of Poole, vast beds of grit? What was the climate on its banks when it washed down the delicate leaves of broad-leaved trees, akin to our modern English ones, which are found in the fine mud-sand strata of Bournemouth? When, finally, did it dwindle down to the brook which

now runs through Wareham town? Was its bed, sea or dry land, or under an ice sheet, during the long ages of the glacial epoch? And if you say—Who is sufficient for these things?—Who can answer these questions? I answer—Who but you, or your pupils after you, if you will but try?

And if any shall reply—And what use if I do try? What use, if I do try? What use if I succeed in answering every question which you have propounded to-night? Shall I be the happier for it? Shall I be the wiser?

My friends, whether you will be the happier for it, or for any knowledge of physical science, or for any other knowledge whatsoever, I cannot tell: that lies in the decision of a Higher Power than I; and, indeed, to speak honestly, I do not think that bio-geology or any other branch of physical science is likely, at first at least, to make you happy. Neither is the study of your fellow-men. Neither is religion itself. We were not sent into the world to be happy, but to be right; at least, poor creatures that we are, as right as we can be; and we must be content with being right, and not happy. For I fear, or rather I hope, that most of us are not capable of carrying out Talleyrand's recipe for perfect happiness on earth—namely, a hard heart and a good digestion. Therefore, as our hearts are, happily, not always hard, and our digestions, unhappily, not always good, we will be content to be made wise by physical science, even though we be not made happy.

And we shall be made truly wise if we be made content; content, too, not only with what we can understand, but, content with what we do not understand—the habit of mind which theologians call—and rightly

—faith in God; the true and solid faith, which comes often out of sadness, and out of doubt, such as bio-geology may well stir in us at first sight. For our first feeling will be—I know mine was when I began to look into these matters—one somewhat of dread and of horror.

Here were all these creatures, animal and vegetable, competing against each other. And their competition was so earnest and complete, that it did not mean—as it does among honest shopkeepers in a civilised country—I will make a little more money than you; but—I will crush you, enslave you, exterminate you, eat you up. "Woe to the weak," seems to be Nature's watchword. The Psalmist says: "The righteous shall inherit the land." If you go to a tropical forest, or, indeed, if you observe carefully a square acre of any English land, cultivated or uncultivated, you will find that Nature's text at first sight looks a very different one. She seems to say: Not the righteous, but the strong, shall inherit the land. Plant, insect, bird, what not—Find a weaker plant, insect, bird, than yourself, and kill it, and take possession of its little vineyard, and no Naboth's curse shall follow you: but you shall inherit, and thrive therein, you, and your children after you, if they will be only as strong and as cruel as you are. That is Nature's law: and is it not at first sight a fearful law? Internecine competition, ruthless selfishness, so internecine and so ruthless that, as I have wandered in tropic forests, where this temper is shown more quickly and fiercely, though not in the least more evilly, than in our slow and cold temperate one, I have said: Really these trees and plants are as wicked as so many human beings.

Throughout the great republic of the organic world,

the motto of the majority is, and always has been as far back as we can see, what it is, and always has been, with the majority of human beings: "Everyone for himself, and the devil take the hindmost." Overreaching tyranny; the temper which fawns, and clings, and plays the parasite as long as it is down, and when it has risen, fattens on its patron's blood and life—these, and the other works of the flesh, are the works of average plants and animals, as far as they can practise them. At least, so says at first sight the science of bio-geology; till the naturalist, if he be also human and humane, is glad to escape from the confusion and darkness of the universal battle-field of selfishness into the order and light of Christmas-tide.

For then there comes to him the thought—And are these all the facts? And is this all which the facts mean? That mutual competition is one law of Nature, we see too plainly. But is there not, besides that law, a law of mutual help? True it is, as the wise man has said, that the very hyssop on the wall grows there because all the forces of the universe could not prevent its growing. All honour to the hyssop. A brave plant, if has fought a brave fight, and has its just deserts—as everything in Nature has—and so has won. But did all the powers of the universe combine to prevent it growing? Is not that a one-sided statement of facts? Did not all the powers of the universe also combine to make it grow, if only it had valour and worth wherewith to grow? Did not the rains feed it, the very mortar in the wall give lime to its roots? Were not electricity, gravitation, and I know not what of chemical and mechanical forces, busy about the little plant, and every cell of it, kindly and patiently ready to help it

if it would only help itself? Surely this is true; true of every organic thing, animal and vegetable, and mineral too, for aught I know: and so we must soften our sadness at the sight of the universal mutual war by the sight of an equally universal mutual help.

But more. It is true—too true if you will—that all things live on each other. But is it not, therefore, equally true that all things live for each other?—that self-sacrifice, and not selfishness, is at the bottom the law of Nature, as it is the law of Grace; and the law of bio-geology, as it is the law of all religion and virtue worthy of the name? Is it not true that everything has to help something else to live, whether it knows it or not?—that not a plant or an animal can turn again to its dust without giving food and existence to other plants, other animals?—that the very tiger, seemingly the most useless tyrant of all tyrants, is still of use, when, after sending out of the world suddenly, and all but painlessly, many an animal which would without him have starved in misery through a diseased old age, he himself dies, and, in dying, gives, by his own carcase, the means of life and of enjoyment to a thousandfold more living creatures than ever his paws destroyed?

And so, the longer one watches the great struggle for existence, the more charitable, the more hopeful, one becomes; as one sees that, consciously or unconsciously, the law of Nature is, after all self-sacrifice: unconscious in plants and animals, as far as we know; save always those magnificent instances of true self-sacrifice shown by the social insects, by ants, bees, and others, which put to shame by a civilisation truly noble —why should I not say divine, for God ordained it?—

the selfishness and barbarism of man. But be that as it may, in man the law of self-sacrifice—whether unconscious or not in the animals—rises into consciousness just as far as he is a man; and the crowning lesson of bio-geology may be, when we have worked it out after all, the lesson of Christmas-tide—of the infinite self-sacrifice of God for man; and Nature as well as religion may say to us:

Ah, could you crush that ever craving lust
For bliss, which kills all bliss, and lose your life,
Your barren unit life, to find again
A thousand times in those for whom you die—
So were you men and women, and should hold
Your rightful rank in God's great universe,
Wherein, in heaven or earth, by will or nature,
Naught lives for self. All, all, from crown to base—
The Lamb, before the world's foundation slain—
The angels, ministers to God's elect—
The sun, who only shines to light the worlds—
The clouds, whose glory is to die in showers—
The fleeting streams, who in their ocean graves
Flee the decay of stagnant self-content—
The oak, ennobled by the shipwright's axe—
The soil, which yields its marrow to the flower—
The flower, which feeds a thousand velvet worms
Born only to be prey to every bird—
All spend themselves on others: and shall man,
Whose twofold being is the mystic knot
Which couples earth with heaven, doubly bound,
As being both worm and angel, to that service
By which both worms and angels hold their life,
Shall he, whose every breath is debt on debt,
Refuse, forsooth, to be what God has made him?
No; let him show himself the creatures' Lord
By free-will gift of that self-sacrifice
Which they, perforce, by Nature's laws endure.

My friends, scientific and others, if the study of bio-geology shall help to teach you this, or anything like this, I think that though it may not make you more happy, it may yet make you more wise; and, therefore, what is better than being more happy, namely, more blessed.

THE STUDY OF NATURAL HISTORY FOR SOLDIERS.

THE STUDY OF NATURAL HISTORY.*

GENTLEMEN: When I accepted the honour of lecturing here, I took for granted that so select an audience would expect from me not mere amusement, but somewhat of instruction; or, if that be too ambitious a word for me to use, at least some fresh hint—if I were able to give one—as to how they should fulfil the ideal of military men in such an age as this.

To touch on military matters, even had I been conversant with them, seemed to me an impertinence. I am bound to take for granted that every man knows his own business best; and I incline more and more to the opinion that military men should be left to work out the problems of their art for themselves, without the advice or criticism of civilians. But I hold—and I am sure that you will agree with me—that if the soldier is to be thus trusted by the nation, and left to himself to do his own work his own way, he must be educated in all practical matters as highly as the average of educated civilians. He must know all that they know, and his own art besides. Just as a clergyman, being

* A Lecture delivered to the Officers of the Royal Artillery, Woolwich, 1872.

a man plus a priest, is bound to be a man, and a good man, over and above his priesthood, so is the soldier bound to be a civilian, and a highly-educated civilian, plus his soldierly qualities and acquirements.

It seemed to me, therefore, that I might, without impertinence, ask you to consider a branch of knowledge which is becoming yearly more and more important in the eyes of well-educated civilians; of which, therefore, the soldier ought at least to know something, in order to put him on a par with the general intelligence of the nation. I do not say that he is to devote much time to it, or to follow it up into specialities: but that he ought to be well grounded in its principles and methods; that he ought to be aware of its importance and its usefulness; that so, if he comes into contact—as he will more and more—with scientific men, he may understand them, respect them, befriend them, and be befriended by them in turn; and how desirable this last result is, I shall tell you hereafter.

There are those, I doubt not, among my audience who do not need the advice which I shall presume to give to-night; who belong to that fast-increasing class among officers of whom I have often said—and I have found scientific men cordially agree with me—that they are the most modest and the most teachable of men. But even in their case there can be no harm in going over deliberately a question of such importance; in putting it, as it were, into shape; and insisting on arguments which may perhaps not have occurred to some of them.

Let me, in the first place, reassure those—if any such there be—who may suppose, from the title of my

lecture, that I am only going to recommend them to collect weeds and butterflies, "rats and mice, and such small deer." Far from it. The honourable title of Natural History has, and unwisely, been restricted too much of late years to the mere study of plants and animals. I desire to restore the words to their original and proper meaning—the History of Nature; that is, of all that is born, and grows in time; in short, of all natural objects.

If any one shall say—By that definition you make not only geology and chemistry branches of natural history, but meteorology and astronomy likewise—I cannot deny it. They deal each of them, with realms of Nature. Geology is, literally, the natural history of soils and lands; chemistry the natural history of compounds, organic and inorganic; meteorology the natural history of climates; astronomy the natural history of planetary and solar bodies. And more, you cannot now study deeply any branch of what is popularly called Natural History—that is, plants and animals—without finding it necessary to learn something, and more and more as you go deeper, of those very sciences. As the marvellous interdependence of all natural objects and forces unfolds itself more and more, so the once separate sciences, which treated of different classes of natural objects, are forced to interpenetrate, as it were; and to supplement themselves by knowledge borrowed from each other. Thus—to give a single instance—no man can now be a first-rate botanist unless he be also no mean meteorologist, no mean geologist, and—as Mr. Darwin has shown in his extraordinary discoveries about the fertilisation of plants by insects—no mean entomologist likewise.

It is difficult, therefore, and indeed somewhat unwise and unfair, to put any limit to the term Natural History, save that it shall deal only with nature and with matter; and shall not pretend—as some would have it to do just now—to go out of its own sphere to meddle with moral and spiritual matters. But, for practical purposes, we may define the natural history of the causes which have made it what it is, and filled it with the natural objects which it holds. And if any one would know how to study the natural history of any given spot as the history of the causes which have made it what it is, and filled it with the natural objects which it holds. And if any one would know how to study the natural history of a place, and how to write it, let him read—and if he has read its delightful pages in youth, read once again—that hitherto unrivalled little monograph, White's "Natural History of Selborne;" and let him then try, by the light of improved science, to do for any district where he may be stationed, what White did for Selborne nearly one hundred years ago. Let him study its plants, its animals, its soils and rocks; and last, but not least, its scenery, as the total outcome of what the soils, and plants, and animals, have made it. I say, have made it. How far the nature of the soils, and the rocks will affect the scenery of a district may be well learnt from a very clever and interesting little book of Professor Geikie's, on "The Scenery of Scotland as affected by its Geological Structure." How far the plants, and trees affect not merely the general beauty, the richness or barrenness of a country, but also its very shape; the rate at which the hills are destroyed and washed into the lowland; the

rate at which the seaboard is being removed by the action of waves—all these are branches of study which is becoming more and more important.

And even in the study of animals and their effects on the vegetation, questions of really deep interest will arise. You will find that certain plants and trees cannot thrive in a district, while others can, because the former are browsed down by cattle, or their seeds eaten by birds, and the latter are not; that certain seeds are carried in the coats of animals, or wafted abroad by winds—others are not; certain trees destroyed wholesale by insects, while others are not; that in a hundred ways the animal and vegetable life of a district act and react upon each other, and that the climate, the average temperature, the maximum and minimum temperatures, the rainfall, act on them, and in the case of the vegetation, are reacted on again by them. The diminution of rainfall by the destruction of forests, its increase by replanting them, and the effect of both on the healthiness or unhealthiness of a place—as in the case of the Mauritius, where a once healthy island has become pestilential, seemingly from the clearing away of the vegetation on the banks of streams—all this, though to study it deeply requires a fair knowledge of meteorology, and even of a science or two more, is surely well worth the attention of any educated man who is put in charge of the health and lives of human beings...

You will surely agree with me that the habit of mind required for such a study as this, is the very same as is required for successful military study. In fact, I should say that the same intellect which would develop into a great military man, would develop also

into a great naturalist. I say, intellect. The military man would require—what the naturalist would not—over and above his intellect, a special force of will, in order to translate his theories into fact, and make his campaigns in the field and not merely on paper. But I am speaking only of the habit of mind required for study; of that inductive habit of mind which works, steadily and by rule, from the known to the unknown; that habit of mind of which it has been said: "The habit of seeing; the habit of knowing what we see; the habit of discerning differences and likenesses; the habit of classifying accordingly; the habit of searching for hypotheses which shall connect and explain those classified facts; the habit of verifying these hypotheses by applying them to fresh facts; the habit of throwing them away bravely if they will not fit; the habit of general patience, diligence, accuracy, reverence for facts for their own sake, and love of truth for its own sake; in one word, the habit of reverent and implicit obedience to the laws of Nature, whatever they may be —these are not merely intellectual, but also moral habits, which will stand men in practical good stead in every affair of life, and in every question, even the most awful, which may come before them as rational and social beings." And specially valuable are they, surely, to the military man, the very essence of whose study, to be successful, lies first in continuous and accurate observation, and then in calm and judicious arrangement.

Therefore it is that I hold, and hold strongly, that the study of physical science, far from interfering with an officer's studies, much less unfitting for them, must assist him in them, by keeping his mind always

in the very attitude and the very temper which they require.

If any smile at this theory of mine, let them recollect one curious fact: that perhaps the greatest captain of the old world was trained by perhaps the greatest philosopher of the old world—the father of Natural History; that Aristotle was the tutor of Alexander of Macedon. I do not fancy, of course, that Aristotle taught Alexander any Natural History. But this we know, that he taught him to use those very faculties by which Aristotle became a natural historian, and many things besides; that he called out in his pupil somewhat of his own extraordinary powers of observation, extraordinary powers of arrangement. He helped to make him a great general: but he helped to make him more—a great politician, coloniser, discoverer. He instilled into him such a sense of the importance of Natural History, that Alexander helped him nobly in his researches; and, if Athenæus is to be believed, gave him eight hundred talents towards perfecting his history of animals. Surely it is not too much to say that this close friendship between the natural philosopher and the soldier has changed the whole course of civilisation to this very day. Do not consider me utopian when I tell you, that I should like to see the study of physical science an integral part of the curriculum of every military school. I would train the mind of the lad who was to become hereafter an officer in the army—and in the navy likewise—by accustoming him to careful observation of, and sound thought about, the face of nature; of the commonest objects under his feet, just as much as the stars above his head; provided always that he learnt, not at second-hand from

books, but where alone he can really learn either war or nature—in the field; by actual observation, actual experiment. A laboratory for chemical experiment is a good thing, it is true, as far as it goes; but I should prefer to the laboratory a naturalists' field-club, such as are prospering now at several of the best public schools, certain that the boys would get more of sound inductive habits of mind, as well as more health, manliness, and cheerfulness, amid scenes to remember which will be a joy for ever, than they ever can by bending over retorts and crucibles, amid smells even to remember which is a pain for ever.

But I would, whether a field-club existed or not, require of every young man entering the army or navy —indeed of every young man entering any liberal profession whatsoever—a fair knowledge, such as would enable him to pass an examination, in what the Germans call *Erd-kunde*—earth-lore—in that knowledge of the face of the earth and of its products, for which we English have as yet cared so little that we have actually no English name for it, save the clumsy and questionable one of physical geography; and, I am sorry to say, hardly any readable school books about it, save Keith Johnston's "Physical Atlas"—an acquaintance with which last I should certainly require of young men.

It does seem most strange—or rather will seem most strange a hundred years hence—that we, the nation of colonists, the nation of sailors, the nation of foreign commerce, the nation of foreign military stations, the nation of travellers for travelling's sake, the nation of which one man here and another there—as Schleiden sets forth in his book, "The Plant," in a charming ideal conversation at the Travellers' Club—has seen and

enjoyed more of the wonders and beauties of this planet than the men of any nation, not even excepting the Germans—that this nation, I say, should as yet have done nothing, or all but nothing, to teach in her schools a knowledge of that planet, of which she needs to know more, and can if she will know more, than any other nation upon it.

As for the practical utility of such studies to a soldier, I only need, I trust, to hint at it to such an assembly as this. All must see of what advantage a rough knowledge of the botany of a district would be to an officer leading an exploring party, or engaged in bush warfare. To know what plants are poisonous; what plants, too, are eatable—and many more are eatable than is usually supposed; what plants yield oleaginous substances, whether for food or for other uses; what plants yield vegetable acids, as preventives of scurvy; what timbers are available for each of many different purposes; what will resist wet, salt-water, and the attacks of insects; what, again, can be used, at a pinch, for medicine or for styptics—and be sure, as a wise West Indian doctor once said to me, that there is more good medicine wild in the bush than there is in all the druggists' shops—surely all this is a knowledge not beneath the notice of any enterprising officer, above all of an officer of engineers. I only ask any one who thinks that I may be in the right, to glance through the lists of useful vegetable products given in Lindley's "Vegetable Kingdom"—a miracle of learning—and see the vast field open still to a thoughtful and observant man, even while on service; and not to forget that such knowledge, if he should hereafter leave the service and settle, as many do, in a distant land, may be a solid help to his future

prosperity. So strongly do I feel on this matter, that I should like to see some knowledge at least of Dr. Oliver's excellent little "First Book of Indian Botany" required of all officers going to our Indian Empire: but as that will not be, at least for many a year to come, I recommend any gentlemen going to India to get that book, and while away the hours of the outward voyage by acquiring knowledge which will be a continual source of interest, and it may be now and then of profit, to them during their stay abroad.

And for geology, again. As I do not expect you all, or perhaps any of you, to become such botanists as General Monro, whose recent "Monograph of the Bamboos" is an honour to British botanists, and a proof of the scientific power which is to be found here and there among British officers: so I do not expect you to become such geologists as Sir Roderick Murchison, or even to add such a grand chapter to the history of extinct animals as Major Cautley did by his discoveries in the Sewalik Hills. Nevertheless, you can learn—and I should earnestly advise you to learn—geology and mineralogy enough to be of great use to you in your profession, and of use, too, should you relinquish your profession hereafter. It must be profitable for any man, and specially for you, to know how and where to find good limestone, building stone, road metal; it must be good to be able to distinguish ores and mineral products; it must be good to know—as a geologist will usually know, even in a country which he sees for the first time—where water is likely to be found, and at what probable depth; it must be good to know whether the water is fit for drinking or not,

whether it is unwholesome or merely muddy; it must be good to know what spots are likely to be healthy, and what unhealthy, for encamping. The two last questions depend, doubtless, on meteorological as well as geological accidents: but the answers to them will be most surely found out by the scientific man, because the facts connected with them are, like all other facts, determined by natural laws. After what one has heard, in past years, of barracks built in spots plainly pestilential; of soldiers encamped in ruined cities, reeking with the dirt and poison of centuries; of—but it is not my place to find fault; all I will say is, that the wise and humane officer, when once his eyes are opened to the practical value of physical science, will surely try to acquaint himself somewhat with those laws of drainage and of climate, geological, meteorological, chemical, which influence, often with terrible suddenness and fury, the health of whole armies. He will not find it beyond his province to ascertain the amount and period of rainfalls, the maxima of heat and of cold which his troops may have to endure, and many another point on which their health and efficiency—nay, their very life may depend, but which are now too exclusively delegated to the doctor, to whose province they do not really belong. For cure, I take the liberty of believing, is the duty of the medical officer; prevention, that of the military.

Thus much I can say just now—and there is much more to be said—on the practical uses of the study of Natural History. But let me remind you, on the other side, if Natural History will help you, you in return can help her; and would, I doubt not, help her and help scientific men at home, if once you looked fairly and

steadily at the immense importance of Natural History —of the knowledge of the "face of the earth." I believe that all will one day feel, more or less, that to know the earth *on* which we live, and the laws of it *by* which we live, is a sacred duty to ourselves, to our children after us, and to all whom we may have to command and to influence; ay, and a duty to God likewise. For is it not a duty of common reverence and faith towards Him, if He has put us into a beautiful and wonderful place, and given us faculties by which we can see, and enjoy, and use that place—is it not a duty of reverence and faith towards Him to use these faculties, and to learn the lessons which He has laid open for us? If you feel that, as I think you all will some day feel, then you will surely feel likewise that it will be a good deed—I do not say a necessary duty, but still a good deed and praiseworthy—to help physical science forward; and to add your contributions, however small, to our general knowledge of the earth. And how much may be done for science by British officers, especially on foreign stations, I need not point out. I know that much has been done, chivalrously and well, by officers; and that men of science owe them and give them hearty thanks for their labours. But I should like, I confess, to see more done still. I should like to see every foreign station what one or two highly-educated officers might easily make it, an advanced post of physical science, in regular communication with our scientific societies at home, sending to them accurate and methodic details of the natural history of each district—details $\frac{9\,9}{1\,0\,0}$ths of which might seem worthless in the eyes of the public, but which would all be precious in the eyes of scientific men, who know that

no fact is really unimportant; and more, that while plodding patiently through seemingly unimportant facts, you may stumble on one of infinite importance, both scientific and practical. For the student of nature, gentlemen, if he will be but patient, diligent, methodical, is liable at any moment to the same good fortune as befell Saul of old, when he went out to seek his father's asses, and found a kingdom.

There are those, lastly, who have neither time nor taste for the technicalities and nice distinctions of formal Natural History; who enjoy Nature, but as artists or as sportsmen, and not as men of science. Let them follow their bent freely: but let them not suppose that in following it they can do nothing towards enlarging our knowledge of Nature, especially when on foreign stations. So far from it, drawings ought always to be valuable, whether of plants, animals, or scenery, provided only they are accurate; and the more spirited and full of genius they are, the more accurate they are certain to be; for Nature being alive, a lifeless copy of her is necessarily an untrue copy. Most thankful to any officer for a mere sight of sketches will be the closest botanist, who, to his own sorrow, knows three-fourths of his plants only from dried specimens; or the closest zoologist, who knows his animals from skins and bones. And if any one answers—But I cannot draw. I rejoin, You can at least photograph. If a young officer, going out to foreign parts, and knowing nothing at all about physical science, did me the honour to ask me what he could do for science, I should tell him—Learn to photograph; take photographs of every strange bit of rock-formation which strikes your fancy, and of every

widely-extended view which may give a notion of the general lie of the country. Append, if you can, a note or two, saying whether a plain is rich or barren; whether the rock is sandstone, limestone, granitic, metamorphic, or volcanic lava; and if there be more rocks than one, which of them lies on the other; and send them to be exhibited at a meeting of the Geological Society. I doubt not that the learned gentlemen there will find in your photographs a valuable hint or two, for which they will be much obliged. I learnt, for instance, what seemed to me most valuable geological lessons from mere glances at drawings—I believe from photographs—of the Abyssinian ranges about Magdala.

Or again, let a man, if he knows nothing of botany, not trouble himself with collecting and drying specimens; let him simply photograph every strange and new tree or plant he sees, to give a general notion of its species, its look; let him append, where he can, a photograph of its leafage, flower, fruit; and send them to Dr. Hooker, or any distinguished botanist: and he will find that, though he may know nothing of botany, he will have pretty certainly increased the knowledge of those who do know.

The sportsman, again—I mean the sportsman of that type which seems peculiar to these islands, who loves toil and danger for their own sakes; he surely is a naturalist, ipso facto, though he knows it not. He has those very habits of keen observation on which all sound knowledge of nature is based; and he, if he will—as he may do without interfering with his sport—can study the habits of the animals among whom he spends wholesome and exciting days. You have only

to look over such good old books as Williams's "Wild Sports of the East," Campbell's "Old Forest Ranger," Lloyd's "Scandinavian Adventures," and last, but not least, Waterton's "Wanderings," to see what valuable additions to true zoology—the knowledge of live creatures, not merely dead ones—British sportsmen have made, and still can make. And as for the employment of time, which often hangs so heavily on a soldier's hands, really I am ready to say, if you are neither men of science, nor draughtsmen, nor sportsmen, why, go and collect beetles. It is not very dignified, I know, nor exciting: but it will be something to do. It cannot harm you, if you take, as beetle-hunters do, an indiarubber sheet to lie on; and it will certainly benefit science. Moreover, there will be a noble humility in the act. You will confess to the public that you consider yourself only fit to catch beetles; by which very confession you will prove yourself fit for much finer things than catching beetles; and meanwhile, as I said before, you will be at least out of harm's way. At a foreign barrack once, the happiest officer I met, because the most regularly employed, was one who spent his time in collecting butterflies. He knew nothing about them scientifically—not even their names. He took them simply for their wonderful beauty and variety; and in the hope, too—in which he was really scientific—that if he carefully kept every form which he saw, his collection might be of use some day to entomologists at home. A most pleasant gentleman he was; and, I doubt not, none the worse soldier for his butterfly catching. Commendable, also, in my eyes, was another officer—whom I have not the pleasure of knowing—who, on a

remote foreign station, used wisely to escape from the temptations of the world into an entirely original and most pleasant hermitage. For finding—so the story went—that many of the finest insects kept to the tree-tops, and never came to ground at all, he used to settle himself among the boughs of some tree in the tropic forests, with a long-handled net and plenty of cigars, and pass his hours in that airy flower-garden, making dashes every now and then at some splendid monster as it fluttered round his head. His example need not be followed by every one; but it must be allowed that —at least as long as he was in his tree—he was neither dawdling, grumbling, spending money, nor otherwise harming himself, and perhaps his fellow-creatures, from sheer want of employment.

One word more, and I have done. If I was allowed to give one special piece of advice to a young officer, whether of the army or navy, I would say: Respect scientific men; associate with them; learn from them; find them to be, as you will usually, the most pleasant and instructive of companions—but always respect them. Allow them chivalrously, you who have an acknowledged rank, their yet unacknowledged rank; and treat them as all the world will treat them in a higher and truer state of civilisation. They do not yet wear the Queen's uniform; they are not yet accepted servants of the State; as they will be in some more perfectly organised and civilised land: but they are soldiers nevertheless, and good soldiers and chivalrous, fighting their nation's battle, often on even less pay than you, and with still less chance of promotion and of fame, against most real and fatal enemies—against ignorance of the laws of this planet, and all the miseries which

that ignorance begets. Honour them for their work; sympathise in it; give them a helping hand in it whenever you have an opportunity—and what opportunities you have, I have been trying to sketch for you to-night; and more, work at it yourselves whenever and wherever you can. Show them that the spirit which animates them—the hatred of ignorance and disorder, and of their bestial consequences—animates you likewise; show them that the habit of mind which they value in themselves—the habit of accurate observation and careful judgment—is your habit likewise; show them that you value science, not merely because it gives better weapons of destruction and of defence, but because it helps you to become clear-headed, large-minded, able to take a just and accurate view of any subject which comes before you, and to cast away every old prejudice and every hasty judgment in the face of truth and of duty: and it will be better for you and for them.

But why? What need for the soldier and the man of science to fraternise just now? This need: the two classes which will have an increasing, it may be a preponderating, influence on the fate of the human race for some time, will be the pupils of Aristotle and those of Alexander—the men of science and the soldiers. In spite of all appearances, and all declamations to the contrary, that is my firm conviction. They, and they alone, will be left to rule; because they alone, each in his own sphere, have learnt to obey. It is therefore most needful for the welfare of society that they should pull with, and not against each other; that they should understand each other, respect each other, take counsel with each

other, supplement each other's defects, bring out each other's higher tendencies, counteract each other's lower ones. The scientific man has something to learn of you, gentlemen, which I doubt not that he will learn in good time. You, again, have—as I have been hinting to you to-night—something to learn of him, which you, I doubt not, will learn in good time likewise. Repeat, each of you according to his powers, the old friendship between Aristotle and Alexander; and so, from your mutual sympathy and co-operation, a class of thinkers and actors may yet arise which can save this nation, and the other civilised nations of the world, from that of which I had rather not speak, and wish that I did not think, too often and too earnestly.

I may be a dreamer; and I may consider, in my turn, as wilder dreamers than myself, certain persons who fancy that their only business in life is to make money, the scientific man's only business is to show them how to make money, and the soldier's only business to guard their money for them. Be that as it may, the finest type of civilised man which we are likely to see for some generations to come, will be produced by a combination of the truly military with the truly scientific man. I say—I may be a dreamer; but you at least, as well as my scientific friends, will bear with me; for my dream is to your honour.

SUPERSTITION.

SUPERSTITION.*

HAVING accepted the very great honour of being allowed to deliver here two lectures, I have chosen as my subject Superstition and Science. It is with Superstition that this first lecture will deal.

The subject seems to me especially fit for a clergyman; for he should, more than other men, be able to avoid trenching on two subjects rightly excluded from this Institution; namely, Theology—that is, the knowledge of God; and Religion—that is, the knowledge of Duty. If he knows, as he should, what is Theology, and what is Religion, then he should best know what is not Theology, and what is not Religion.

For my own part, I entreat you at the outset to keep in mind that these lectures treat of matters entirely physical; which have in reality, and ought to have in our minds, no more to do with Theology and Religion than the proposition that theft is wrong, has to do with the proposition that the three angles of a triangle are equal to two right angles.

* A Lecture delivered at the Royal Institution, London, 1867.

It is necessary to premise this, because many are of opinion that superstition is a corruption of religion; and though they would agree that as such, "corruptio optimi pessima," yet they would look on religion as the state of spiritual health, and superstition as one of spiritual disease.

Others again, holding the same notion, but not considering that "corruptio optimi pessima," have been in all ages somewhat inclined to be merciful to superstition, as a child of reverence; as a mere accidental misdirection of one of the noblest and most wholesome faculties of man.

This is not the place wherein to argue with either of these parties: and I shall simply say that superstition seems to me altogether a physical affection, as thoroughly material and corporeal as those of eating or sleeping, remembering or dreaming.

After this, it will be necessary to define superstition, in order to have some tolerably clear understanding of what we are talking about. I beg leave to define it as—Fear of the unknown.

Johnson, who was no dialectician, and, moreover, superstitious enough himself, gives eight different definitions of the word; which is equivalent to confessing his inability to define it at all:

"1. Unnecessary fear or scruples in religion; observance of unnecessary and uncommanded rites or practices; religion without morality.

"2. False religion; reverence of beings not proper objects of reverence; false worship.

"3. Over nicety; exactness too scrupulous."

Eight meanings; which, on the principle that eight eighths, or indeed eight hundred, do not make one

whole, may be considered as no definition. His first thought, as often happens, is the best—"Unnecessary fear." But after that he wanders. The root-meaning of the word is still to seek. But, indeed, the popular meaning, thanks to popular common sense, will generally be found to contain in itself the root-meaning.

Let us go back to the Latin word Superstitio. Cicero says that the superstitious element consists in "a certain empty dread of the gods"—a purely physical affection, if you will remember three things:

1. That dread is in itself a physical affection.

2. That the gods who were dreaded were, with the vulgar, who alone dreaded them, merely impersonations of the powers of nature.

3. That it was physical injury which these gods were expected to inflict.

But he himself agrees with this theory of mine; for he says shortly after, that not only philosophers, but even the ancient Romans, had separated superstition from religion; and that the word was first applied to those who prayed all day *ut liberi sui sibi superstites essent*, might survive them. On the etymology no one will depend who knows the remarkable absence of any etymological instinct in the ancients, in consequence of their weak grasp of that sound inductive method which has created modern criticism. But if it be correct, it is a natural and pathetic form for superstition to take in the minds of men who saw their children fade and die; probably the greater number of them beneath diseases which mankind could neither comprehend nor cure.

The best exemplification of what the ancients

meant by superstition is to be found in the lively and dramatic words of Aristotle's great pupil Theophrastus.

The superstitious man, according to him, after having washed his hands with lustral water—that is, water in which a torch from the altar had been quenched—goes about with a laurel-leaf in his mouth, to keep off evil influences, as the pigs in Devonshire used, in my youth, to go about with a withe of mountain ash round their necks to keep off the evil eye. If a weasel crosses his path, he stops, and either throws three pebbles into the road, or, with the innate selfishness of fear, lets someone else go before him, and attract to himself the harm which may ensue. He has a similar dread of a screech-owl, whom he compliments in the name of its mistress, Pallas Athene. If he finds a serpent in his house, he sets up an altar to it. If he pass at a four-cross-way an anointed stone, he pours oil on it, kneels down, and adores it. If a rat has nibbled one of his sacks he takes it for a fearful portent—a superstition which Cicero also mentions. He dare not sit on a tomb, because it would be assisting at his own funeral. He purifies endlessly his house, saying that Hecate—that is, the moon—has exercised some malign influence on it; and many other purifications he observes, of which I shall only say that they are by their nature plainly, like the last, meant as preservatives against unseen malarias or contagions, possible or impossible. He assists every month with his children at the mysteries of the Orphic priests; and finally, whenever he sees an epileptic patient, he spits in his own bosom to avert the evil omen.

I have quoted, I believe, every fact given by Theophrastus; and you will agree, I am sure, that the moving and inspiring element of such a character is mere bodily fear of unknown evil. The only superstition attributed to him which does not at first sight seem to have its root in dread is that of the Orphic mysteries. But of them Müller says that the Dionusos whom they worshipped "was an infernal deity, connected with Hades, and was the personification, not merely of rapturous pleasure, but of a deep sorrow for the miseries of human life." The Orphic societies of Greece seem to have been peculiarly ascetic, taking no animal food save raw flesh from the sacrificed ox of Dionusos. And Plato speaks of a lower grade of Orphic priests, Orpheotelestai, "who used to come before the doors of the rich, and promise, by sacrifices and expiatory songs, to release them from their own sins, and those of their forefathers;" and such would be but too likely to get a hearing from the man who was afraid of a weasel or an owl.

Now, this same bodily fear, I verily believe, will be found at the root of all superstition whatsoever.

But be it so. Fear is a natural passion, and a wholesome one. Without the instinct of self-preservation, which causes the sea-anemone to contract its tentacles, or the fish to dash into its hover, species would be extermined wholesale by involuntary suicide.

Yes; fear is wholesome enough, like all other faculties, as long as it is controlled by reason. But what if the fear be not rational, but irrational? What if it be, in plain homely English, blind fear; fear of

the unknown, simply because it is unknown? Is it not likely, then, to be afraid of the wrong object? to be hurtful, ruinous to animals as well as to man? Any one will confess that, who has ever seen a horse inflict on himself mortal injuries, in his frantic attempts to escape from a quite imaginary danger. I have good reasons for believing that not only animals here and there, but whole flocks and swarms of them, are often destroyed, even in the wild state, by mistaken fear; by such panics, for instance, as cause a whole herd of buffaloes to rush over a bluff, and be dashed to pieces. And remark that this capacity of panic, fear—of superstition, as I should call it—is greatest in those animals, the dog and the horse for instance, which have the most rapid and vivid fancy. Does not the unlettered Highlander say all that I want to say, when he attributes to his dog and his horse, on the strength of these very manifestations of fear, the capacity of seeing ghosts and fairies before he can see them himself?

But blind fear not only causes evil to the coward himself: it makes him a source of evil to others; for it is the cruellest of all human states. It transforms the man into the likeness of the cat, who, when she is caught in a trap, or shut up in a room, has too low an intellect to understand that you wish to release her: and, in the madness of terror, bites and tears at the hand which tries to do her good. Yes; very cruel is blind fear. When a man dreads he knows not what, he will do he cares not what. When he dreads desperately, he will act desperately. When he dreads beyond all reason, he will behave beyond all reason. He has no law of guidance left, save the lowest selfishness. No

law of guidance: and yet his intellect, left unguided, may be rapid and acute enough to lead him into terrible follies. Infinitely more imaginative than the lowest animals, he is for that very reason capable of being infinitely more foolish, more cowardly, more superstitious. He can—what the lower animals, happily for them, cannot—organise his folly; erect his superstitions into a science; and create a whole mythology out of his blind fear of the unknown. And when he has done that—Woe to the weak! For when he has reduced his superstition to a science, then he will reduce his cruelty to a science likewise, and write books like the "Malleus Maleficarum," and the rest of the witch literature of the fifteenth, sixteenth, and seventeenth centuries; of which Mr. Lecky has of late told the world so much, and told it most faithfully and most fairly.

But, fear of the unknown? Is not that fear of the unseen world? And is not that fear of the spiritual world? Pardon me: a great deal of that fear—all of it, indeed, which is superstition—is simply not fear of the spiritual, but of the material; and of nothing else.

The spiritual world—I beg you to fix this in your minds—is not merely an invisible world which may become visible, but an invisible world which is by its essence invisible; a moral world, a world of right and wrong. And spiritual fear—which is one of the noblest of all affections, as bodily fear is one of the basest—is, if properly defined, nothing less or more than the fear of doing wrong; of becoming a worse man.

But what has that to do with mere fear of the unseen? The fancy which conceives the fear is physical, not spiritual. Think for yourselves. What difference is

there between a savage's fear of a demon, and a hunter's fear of a fall? The hunter sees a fence. He does not know what is on the other side, but he has seen fences like it with a great ditch on the other side, and suspects one here likewise. He has seen horses fall at such, and men hurt thereby. He pictures to himself his horse falling at that fence, himself rolling in the ditch, with possibly a broken limb; and he recoils from the picture he himself has made; and perhaps with very good reason. His picture may have its counterpart in fact; and he may break his leg. But his picture, like the previous pictures from which it was compounded, is simply a physical impression on the brain, just as much as those in dreams.

Now, does the fact of the ditch, the fall, and the broken leg, being unseen and unknown, make them a spiritual ditch, a spiritual fall, a spiritual broken leg? And does the fact of the demon and his doings, being as yet unseen and unknown, make them spiritual, or the harm that he may do, a spiritual harm? What does the savage fear? Lest the demon should appear; that is, become obvious to his physical senses, and produce an unpleasant physical effect on them. He fears lest the fiend should entice him into the bog, break the hand-bridge over the brook, turn into a horse and ride away with him, or jump out from behind a tree and wring his neck—tolerably hard physical facts, all of them; the children of physical fancy, regarded with physical dread. Even if the superstition proved true; even if the demon did appear; even if he wrung the traveller's neck in sound earnest, there would be no more spiritual agency or phenomenon in the whole tragedy than there is in the parlour-table, when

spiritual somethings make spiritual raps upon spiritual wood; and human beings, who are really spirits—and would to heaven they would remember that fact, and what it means—believe that anything has happened beyond a clumsy juggler's trick.

You demur? Do you not see that the demon, by the mere fact of having produced physical consequences, would have become himself a physical agent, a member of physical Nature, and therefore to be explained, he and his doings, by physical laws? If you do not see that conclusion at first sight, think over it till you do.

It may seem to some that I have founded my theory on a very narrow basis; that I am building up an inverted pyramid; or that, considering the numberless, complex, fantastic shapes which superstition has assumed, bodily fear is too simple to explain them all.

But if those persons will think a second time, they must agree that my base is as broad as the phenomena which it explains; for every man is capable of fear. And they will see, too, that the cause of superstition must be something like fear, which is common to all men: for all, at least as children, are capable of superstition; and that it must be something which, like fear, is of a most simple, rudimentary, barbaric kind; for the lowest savage, of whatever he is not capable, is still superstitious, often to a very ugly degree. Superstition seems, indeed, to be, next to the making of stone-weapons, the earliest method of asserting his superiority to the brutes which has occurred to that utterly abnormal and fantastic *lusus naturæ* called man.

Now let us put ourselves awhile, as far as we can, in the place of that same savage; and try whether my theory will not justify itself; whether or not super-

stition, with all its vagaries, may have been, indeed must have been, the result of that ignorance and fear which he carried about with him, every time he prowled for food through the primeval forest.

A savage's first division of nature would be, I should say, into things which he can eat and things which can eat him: including, of course, his most formidable enemy, and most savoury food—his fellow-man. In finding out what he can eat, we must remember, he will have gone through much experience which will have inspired him with a serious respect for the hidden wrath of nature; like those Himalayan folk, of whom Hooker says, that as they know every poisonous plant, they must have tried them all — not always with impunity.

So he gets at a third class of objects—things which he cannot eat, and which will not eat him; but will only do him harm, as it seems to him, out of pure malice, like poisonous plants and serpents. There are natural accidents, too, which fall into the same category, stones, floods, fires, avalanches. They hurt him or kill him, surely for ends of their own. If a rock falls from the cliff above him, what more natural than to suppose that there is some giant up there who threw it at him? If he had been up there, and strong enough, and had seen a man walking underneath, he would certainly have thrown the stone at him and killed him. For first, he might have eaten the man after; and even if he were not hungry, the man might have done him a mischief; and it was prudent to prevent that by doing him a mischief first. Besides, the man might have a wife; and if he killed the man, then the wife would, by a very ancient law common to man and animals,

become the prize of the victor. Such is the natural man, the carnal man, the soulish man, the ἄνθρωπος ψυχικὸς of St. Paul, with five tolerably acute senses, which are ruled by five very acute animal passions—hunger, sex, rage, vanity, fear. It is with the working of the last passion, fear, that this lecture has to do.

So the savage concludes that there must be a giant living in the cliff, who threw stones at him, with evil intent; and he concludes in like wise concerning most other natural phenomena. There is something in them which will hurt him, and therefore likes to hurt him; and if he cannot destroy them, and so deliver himself, his fear of them grows quite boundless. There are hundreds of natural objects on which he learns to look with the same eyes as the little boys of Teneriffe look on the useless and poisonous *Euphorbia canariensis*. It is to them—according to Mr. Piazzi Smyth—a demon who would kill them, if it could only run after them; but as it cannot, they shout Spanish curses at it, and pelt it with volleys of stones, "screeching with elfin joy, and using worse names than ever, when the poisonous milk spurts out from its bruised stalks."

And if such be the attitude of the uneducated man towards the permanent terrors of nature, what will it be towards those which are sudden and seemingly capricious?—towards storms, earthquakes, floods, blights, pestilences? We know too well what it has been—one of blind, and therefore often cruel, fear. How could it be otherwise? Was Theophrastus's superstitious man so very foolish for pouring oil on every round stone? I think there was a great deal to be said for him. This worship of Bætyli was rational enough. They were aerolites, fallen from heaven.

Was it not as well to be civil to such messengers from above?—to testify by homage to them due awe of the being who had thrown them at men, and who though he had missed his shot that time might not miss it the next? I think if we, knowing nothing of either gunpowder, astronomy, or Christianity, saw an Armstrong bolt fall within five miles of London, we should be inclined to be very respectful to it indeed. So the aerolites, or glacial boulders, or polished stone weapons of an extinct race, which looked like aerolites, were the children of Ouranos the heaven, and had souls in them. One, by one of those strange transformations in which the logic of unreason indulges, the image of Diana of the Ephesians, which fell down from Jupiter; another was the Ancile, the holy shield which fell from the same place in the days of Numa Pompilius, and was the guardian genius of Rome; and several more became notable for ages.

Why not? The uneducated man of genius, unacquainted alike with metaphysics and with biology, sees, like a child, a personality in every strange and sharply-defined object. A cloud like an angel may be an angel; a bit of crooked root like a man may be a man turned into wood—perhaps to be turned back again at its own will. An erratic block has arrived where it is by strange unknown means. Is not that an evidence of its personality? Either it has flown hither itself, or some one has thrown it. In the former case, it has life, and is proportionally formidable; in the latter, he who had thrown it is formidable.

I know two erratic blocks of porphyry—I believe there are three—in Cornwall, lying one on serpentine, one, I think, on slate, which—so I was always informed

as a boy—were the stones which St. Kevern threw after St. Just when the latter stole his host's chalice and paten, and ran away with them to the Land's End. Why not? Before we knew anything about the action of icebergs and glaciers, that is, until the last eighty years, that was as good a story as any other; while how lifelike these boulders are, let a great poet testify; for the fact has not escaped the delicate eye of Wordsworth:

> As a huge stone is sometimes seen to lie
> Couched on the bald top of an eminence;
> Wonder to all who do the same espy,
> By what means it could thither come, and whence,
> So that it seems a thing endued with sense;
> Like a sea-beast crawled forth, that on a shelf
> Of rock or sand reposeth, there to sun itself.

To the civilised poet, the fancy becomes a beautiful simile; to a savage poet, it would have become a material and a very formidable fact. He stands in the valley, and looks up at the boulder on the far-off fells. He is puzzled by it. He fears it. At last he makes up his mind. It is alive. As the shadows move over it, he sees it move. May it not sleep there all day, and prowl for prey all night? He had been always afraid of going up those fells; now he will never go. There is a monster there.

Childish enough, no doubt. But remember that the savage is always a child. So, indeed, are millions, as well clothed, housed, and policed as ourselves—children from the cradle to the grave. But of them I do not talk; because, happily for the world, their childishness is so overlaid by the result of other men's manhood;

by an atmosphere of civilisation and Christianity which they have accepted at second-hand as the conclusions of minds wiser than their own, that they do all manner of reasonable things for bad reasons, or for no reason at all, save the passion of imitation. Not in them, but in the savage, can we see man as he is by nature, the puppet of his senses and his passions, the natural slave of his own fears.

But has the savage no other faculties, save his five senses and five passions? I do not say that. I should be most unphilosophical if I said it; for the history of mankind proves that he has infinitely more in him than that. Yes: but in him that infinite more, which is not only the noblest part of humanity, but, it may be, humanity itself, is not to be counted as one of the roots of superstition. For in the savage man, in whom superstition certainly originates, that infinite more is still merely in him; inside him; a faculty: but not yet a fact. It has not come out of him into consciousness, purpose, and act; and is to be treated as non-existent: while what has come out, his passions and senses, is enough to explain all the vagaries of superstition; a *vera causa* for all its phenomena. And if we seem to have found a sufficient explanation already, it is unphilosophical to look farther, at least till we have tried whether our explanation fits the facts.

Nevertheless, there is another faculty in the savage, to which I have already alluded, common to him and to at least the higher vertebrates—fancy; the power of reproducing internal images of external objects, whether in its waking form of physical memory—if, indeed, all memory be not physical—or in its sleeping form of dreaming. Upon this last, which has played

so very important a part in superstition in all ages, I beg you to think a moment. Recollect your own dreams during childhood; and recollect again that the savage is always a child. Recollect how difficult it was for you in childhood, how difficult it must be always for the savage, to decide whether dreams are phantasms or realities. To the savage, I doubt not, the food he eats, the foes he grapples with, in dreams, are as real as any waking impressions. But, moreover, these dreams will be very often, as children's dreams are wont to be, of a painful and terrible kind. Perhaps they will be always painful; perhaps his dull brain will never dream, save under the influence of indigestion, or hunger, or an uncomfortable attitude. And so, in addition to his waking experience of the terrors of nature, he will have a whole dream-experience besides, of a still more terrific kind. He walks by day past a black cavern mouth, and thinks, with a shudder—Something ugly may live in that ugly hole: what if it jumped out upon me? He broods over the thought with the intensity of a narrow and unoccupied mind; and a few nights after, he has eaten—but let us draw a veil before the larder of a savage—his chin is pinned down on his chest, a slight congestion of the brain comes on; and behold he finds himself again at that cavern's mouth, and something ugly does jump out upon him: and the cavern is a haunted spot henceforth to him and to all his tribe. It is in vain that his family tell him that he has been lying asleep at home all the while. He has the evidence of his senses to prove the contrary. He must have got out of himself, and gone into the woods. When we remember that certain wise Greek philosophers could find no better explanation

of dreaming than that the soul left the body, and wandered free, we cannot condemn the savage for his theory.

Now, I submit that in these simple facts we have a group of "true causes" which are the roots of all the superstitions of the world.

And if any one shall complain that I am talking materialism: I shall answer, that I am doing exactly the opposite. I am trying to eliminate and get rid of that which is material, animal, and base; in order that that which is truly spiritual may stand out, distinct and clear, in its divine and eternal beauty.

To explain, and at the same time, as I think, to verify my hypothesis, let me give you an example—fictitious, it is true, but probable fact nevertheless; because it is patched up of many fragments of actual fact: and let us see how, in following it out, we shall pass through almost every possible form of superstition.

Suppose a great hollow tree, in which the formidable wasps of the tropics have built for ages. The average savage hurries past the spot in mere bodily fear; for if they come out against him, they will sting him to death; till at last there comes by a savage wiser than the rest, with more observation, reflection, imagination, independence of will—the genius of his tribe.

The awful shade of the great tree, added to his terror of the wasps, weighs on him, and excites his brain. Perhaps, too, he has had a wife or a child stung to death by these same wasps. These wasps, so small, yet so wise, far wiser than he: they fly, and they sting. Ah, if he could fly and sting; how he would kill and eat, and live right merrily. They build great

towns; they rob far and wide; they never quarrel with each other: they must have some one to teach them, to lead them—they must have a king. And so he gets the fancy of a Wasp-King; as the western Irish still believe in the Master Otter; as the Red Men believe in the King of the Buffaloes, and find the bones of his ancestors in the Mammoth remains of Big-bone Lick; as the Philistines of Ekron—to quote a notorious instance—actually worshipped Baal-zebub, lord of the flies.

If they have a king, he must be inside that tree, of course. If he, the savage, were a king, he would not work for his bread, but sit at home and make others feed him; and so, no doubt, does the wasp-king.

And when he goes home he will brood over this wonderful discovery of the wasp-king; till, like a child, he can think of nothing else. He will go to the tree, and watch for him to come out. The wasps will get accustomed to his motionless figure, and leave him unhurt; till the new fancy will rise in his mind that he is a favourite of this wasp-king: and at last he will find himself grovelling before the tree, saying—"Oh great wasp-king, pity me, and tell your children not to sting me, and I will bring you honey, and fruit, and flowers to eat, and I will flatter you, and worship you, and you shall be my king."

And then he would gradually boast of his discovery; of the new mysterious bond between him and the wasp-king; and his tribe would believe him, and fear him; and fear him still more when he began to say, as he surely would, not merely—"I can ask the wasp-king, and he will tell his children not to sting you:" but—"I can ask the wasp-king, and he will send his children,

and sting you all to death." Vanity and ambition will have prompted the threat: but it will not be altogether a lie. The man will more than half believe his own words; he will quite believe them when he has repeated them a dozen times.

And so he will become a great man, and a king, under the protection of the king of the wasps; and he will become, and it may be his children after him, priest of the wasp-king, who will be their fetish, and the fetish of their tribe.

And they will prosper, under the protection of the wasp-king. The wasp will become their moral ideal, whose virtues they must copy. The new chief will preach to them wild eloquent words. They must sting like wasps, revenge like wasps, hold altogether like wasps, build like wasps, work hard like wasps, rob like wasps; then, like the wasps, they will be the terror of all around, and kill and eat all their enemies. Soon they will call themselves The Wasps. They will boast that their king's father or grandfather, and soon that the ancestor of the whole tribe was an actual wasp; and the wasp will become at once their *eponym* hero, their deity, their ideal, their civiliser; who has taught them to build a kraal of huts, as he taught his children to build a hive.

Now, if there should come to any thinking man of this tribe, at this epoch, the new thought—Who made the world? he will be sorely puzzled. The conception of a world has never crossed his mind before. He never pictured to himself anything beyond the nearest ridge of mountains; and as for a Maker, that will be a greater puzzle still. What makers or builders more cunning than those wasps of whom his foolish head is full? Of

course, he sees it now. A Wasp made the world; which to him entirely new guess might become an integral part of his tribe's creed. That would be their cosmogony. And if, a generation or two after, another savage genius should guess that the world was a globe hanging in the heavens, he would, if he had imagination enough to take the thought in at all, put it to himself in a form suited to his previous knowledge and conceptions. It would seem to him that The Wasp flew about the skies with the world in his mouth, as he carries a bluebottle fly; and that would be the astronomy of his tribe henceforth. Absurd enough: but—as every man who is acquainted with old mythical cosmogonies must know—no more absurd than twenty similar guesses on record. Try to imagine the gradual genesis of such myths as the Egyptian scarabæus and egg, or the Hindoo theory that the world stood on an elephant, the elephant on a tortoise, the tortoise on that infinite note of interrogation which, as some one expresses it, underlies all physical speculations, and judge: must they not have arisen in some such fashion as that which I have pointed out?

This, I say, would be the culminating point of the wasp-worship, which had sprung up out of bodily fear of being stung.

But times might come for it in which it would go through various changes, through which every superstition in the world, I suppose, has passed or is doomed to pass.

The wasp-men might be conquered, and possibly eaten, by a stronger tribe than themselves. What would be the result? They would fight valiantly at first, like wasps. But what if they began to fail?

Was not the wasp-king angry with them? Had not he deserted them? He must be appeased; he must have his revenge. They would take a captive, and offer him to the wasps. So did a North American tribe, in their need, some forty years ago; when, because their maize-crops failed, they roasted alive a captive girl, cut her to pieces, and sowed her with their corn. I would not tell the story, for the horror of it, did it not bear with such fearful force on my argument. What were those Red Men thinking of? What chain of misreasoning had they in their heads when they hit on that as a device for making the crops grow? Who can tell? Who can make the crooked straight, or number that which is wanting? As said Solomon of old, so must we—"The foolishness of fools is folly." One thing only we can say of them, that they were horribly afraid of famine, and took that means of ridding themselves of their fear.

But what if the wasp tribe had no captives? They would offer slaves. What if the agony and death of slaves did not appease the wasps? They would offer their fairest, their dearest, their sons and their daughters, to the wasps; as the Carthaginians, in like strait, offered in one day 200 noble boys to Moloch, the volcano-god, whose worship they had brought out of Syria; whose original meaning they had probably forgotten; of whom they only knew that he was a dark and devouring being, who must be appeased with the burning bodies of their sons and daughters. And so the veil of fancy would be lifted again, and the whole superstition stand forth revealed as the mere offspring of bodily fear.

But more: the survivors of the conquest might,

perhaps, escape, and carry their wasp-fetish into a new land. But if they became poor and weakly, their brains and imagination, degenerating with their bodies, would degrade their wasp-worship till they knew not what it meant. Away from the sacred tree, in a country the wasps of which were not so large or formidable, they would require a remembrancer of the wasp-king; and they would make one—a wasp of wood, or what not. After a while, according to that strange law of fancy, the root of all idolatry, which you may see at work in every child who plays with a doll, the symbol would become identified with the thing symbolised; they would invest the wooden wasp with all the terrible attributes which had belonged to the live wasps of the tree; and after a few centuries, when all remembrance of the tree, the wasp-prophet and chieftain, and his descent from the divine wasp—ay, even of their defeat and flight—had vanished from their songs and legends, they would be found bowing down in fear and trembling to a little ancient wooden wasp, which came from they knew not whence, and meant they knew not what, save that it was a very "old fetish," a "great medicine," or some such other formula for expressing their own ignorance and dread. Just so do the half-savage natives of Thibet, and the Irishwomen of Kerry, by a strange coincidence—unless the ancient Irish were Buddhists, like the Himalayans—tie just the same scraps of rag on the bushes round just the same holy wells, as do the Negros of Central Africa upon their "Devil's Trees;" they know not why, save that their ancestors did it, and it is a charm against ill-luck and danger.

And the sacred tree? That, too, might undergo a

metamorphosis in the minds of men. The conquerors would see their aboriginal slaves of the old race still haunting the tree, making stealthy offerings to it by night: and they would ask the reason. But they would not be told. The secret would be guarded; such secrets were guarded, in Greece, in Italy, in medieval France, by the superstitious awe, the cunning, even the hidden self-conceit, of the conquered race. Then the conquerors would wish to imitate their own slaves. They might be in the right. There might be something magical, uncanny, in the hollow tree, which might hurt them; might be jealous of them as intruders. They, too, would invest the place with sacred awe. If they were gloomy, like the Teutonic conquerors of Europe and the Arabian conquerors of the East, they would invest it with unseen terrors. They would say, like them, a devil lives in the tree. If they were of a sunny temper, like the Hellenes, they would invest it with unseen graces. What a noble tree! What a fair fountain hard by its roots! Surely some fair and graceful being must dwell therein, and come out to bathe by night in that clear wave. What meant the fruit, the flowers, the honey, which the slaves left there by night? Pure food for some pure nymph. The wasp-gods would be forgotten; probably smoked out as sacrilegious intruders. The lucky seer or poet who struck out the fancy would soon find imitators; and it would become, after a while, a common and popular superstition that Hamadryads haunted the hollow forest trees, Naiads the wells, and Oreads the lawns. Somewhat thus, I presume, did the more cheerful Hellenic myths displace the darker superstitions of the Pelasgi, and those rude Arcadian tribes who offered, even as

late as the Roman Empire, human sacrifices to gods whose original names were forgotten.

But even the cultus of nymphs would be defiled after awhile by a darker element. However fair, they might be capricious and revengeful, like other women. Why not? And soon, men going out into the forest would be missed for awhile. They had eaten narcotic berries, got sun-strokes, wandered till they lost their wits. At all events, their wits were gone. Who had done it? Who but the nymphs? The men had seen something they should not have seen; done something they would not have done; and the nymphs had punished the unconscious rudeness by that frenzy. Fear, everywhere fear, of Nature—the spotted panther, as some one calls her, as fair as cruel, as playful as treacherous. Always fear of Nature, till a Divine light arise, and show men that they are not the puppets of Nature, but her lords; and that they are to fear God, and fear naught else.

And so ends my true myth of the wasp-tree. No, it need not end there; it may develop into a yet darker and more hideous form of superstition, which Europe has often seen; which is common now among the Negros;* which we may hope, will soon be exterminated.

This might happen. For it, or something like it, has happened too many times already.

That to the ancient women who still kept up the irrational remnant of the wasp-worship, beneath the sacred tree, other women might resort; not merely

* For an account of Sorcery and Fetishism among the African Negros, see Burton's "Lake Regions of Central Africa," vol. ii. pp. 341–60.

from curiosity, or an excited imagination, but from jealousy and revenge. Oppressed, as woman has always been under the reign of brute force; beaten, outraged, deserted, at best married against her will, she has too often gone for comfort and help—and those of the very darkest kind—to the works of darkness; and there never were wanting—there are not wanting, even now, in remote parts of these isles—wicked old women who would, by help of the old superstitions, do for her what she wished. Soon would follow mysterious deaths of rivals, of husbands, of babes; then rumours of dark rites connected with the sacred tree, with poison, with the wasp and his sting, with human sacrifices; lies mingled with truth, more and more confused and frantic, the more they were misinvestigated by men mad with fear: till there would arise one of those witch-manias, which are too common still among the African Negros, which were too common of old among the men of our race.

I say, among the men. To comprehend a witch-mania, you must look at it as—what the witch-literature confesses it unblushingly to be—man's dread of Nature excited to its highest form, as dread of woman.

She is to the barbarous man—she should be more and more to the civilised man—not only the most beautiful and precious, but the most wonderful and mysterious of all natural objects, if it be only as the author of his physical being. She is to the savage a miracle to be alternately adored and dreaded. He dreads her more delicate nervous organisation, which often takes shapes to him demoniacal and miraculous;

her quicker instincts, her readier wit, which seem to him to have in them somewhat prophetic and superhuman, which entangled him as in an invisible net, and rule him against his will. He dreads her very tongue, more crushing than his heaviest club, more keen than his poisoned arrows. He dreads those habits of secrecy and falsehood, the weapons of the weak, to which savage and degraded woman always has recourse. He dreads the very medicinal skill which she has learnt to exercise, as nurse, comforter, and slave. He dreads those secret ceremonies, those mysterious initiations which no man may witness, which he has permitted to her in all ages, in so many —if not all—barbarous and semi-barbarous races, whether Negro, American, Syrian, Greek, or Roman, as a homage to the mysterious importance of her who brings him into the world. If she turns against him —she, with all her unknown powers, she who is the sharer of his deepest secrets, who prepares his very food day by day—what harm can she not, may she not, do? And that she has good reason to turn against him, he knows too well. What deliverance is there from this mysterious house-fiend, save brute force? Terror, torture, murder, must be the order of the day. Woman must be crushed, at all price, by the blind fear of the man.

I shall say no more. I shall draw a veil, for very pity and shame, over the most important and most significant facts of this, the most hideous of all human follies. I have, I think, given you hints enough to show that it, like all other superstitions, is the child—the last born and the ugliest child—of blind dread of the unknown.

SCIENCE.

SCIENCE.*

I SAID, that Superstition was the child of Fear, and Fear the child of Ignorance; and you might expect me to say antithetically, that Science was the child of Courage, and Courage the child of Knowledge.

But these genealogies—like most metaphors—do not fit exactly, as you may see for yourselves.

If fear be the child of ignorance, ignorance is also the child of fear; the two react on, and produce each other. The more men dread Nature, the less they wish to know about her. Why pry into her awful secrets? It is dangerous; perhaps impious. She says to them, as in the Egyptian temple of old—"I am Isis, and my veil no mortal yet hath lifted." And why should they try or wish to lift it? If she will leave them in peace, they will leave her in peace. It is enough that she does not destroy them. So as ignorance bred fear, fear breeds fresh and willing ignorance.

And courage? We may say, and truly, that courage is the child of knowledge. But we may say as truly,

* A Lecture delivered at the Royal Institution.

that knowledge is the child of courage. Those Egyptian priests in the temple of Isis would have told you that knowledge was the child of mystery, of special illumination, of reverence, and what not; hiding under grand words their purpose of keeping the masses ignorant, that they might be their slaves. Reverence? I will yield to none in reverence for reverence. I will all but agree with the wise man who said that reverence is the root of all virtues. But which child reverences his father most? He who comes joyfully and trustfully to meet him, that he may learn his father's mind, and do his will; or he who at his father's coming runs away and hides, lest he should be beaten for he knows not what? There is a scientific reverence, a reverence of courage, which is surely one of the highest forms of reverence. That, namely, which so reveres every fact, that it dare not overlook or falsify it, seem it never so minute; which feels that because it is a fact it cannot be minute, cannot be unimportant; that it must be a fact of God; a message from God; a voice of God, as Bacon has it, revealed in things; and which therefore, just because it stands in solemn awe of such paltry facts as the Scolopax feather in a snipe's pinion, or the jagged leaves which appear capriciously in certain honeysuckles, believes that there is likely to be some deep and wide secret underlying them, which is worth years of thought to solve. That is reverence; a reverence which is growing, thank God, more and more common; which will produce, as it grows more common still, fruit which generations yet unborn shall bless.

But as for that other reverence, which shuts its eyes and ears in pious awe—what is it but cowardice decked

out in state robes, putting on the sacred Urim and Thummim, not that men may ask counsel of the Deity, but that they may not? What is it but cowardice, very pitiable when unmasked; and what is its child but ignorance as pitiable, which would be ludicrous were it not so injurious? If a man comes up to Nature as to a parrot or a monkey, with this prevailing thought in his head—Will it bite me?—will he not be pretty certain to make up his mind that it may bite him, and had therefore best be left alone? It is only the man of courage—few and far between—who will stand the chance of a first bite, in the hope of teaching the parrot to talk, or the monkey to fire off a gun. And it is only the man of courage—few and far between—who will stand the chance of a first bite from Nature, which may kill him for aught he knows—for her teeth, though clumsy, are very strong—in order that he may tame her and break her in to his use by the very same method by which that admirable inductive philosopher, Mr. Rarey, used to break in his horses; first, by not being afraid of them; and next, by trying to find out what they were thinking of. But after all, as with animals, so with Nature; cowardice is dangerous. The surest method of getting bitten by an animal is to be afraid of it; and the surest method of being injured by Nature is to be afraid of it. Only as far as we understand Nature are we safe from it; and those who in any age counsel mankind not to pry into the secrets of the universe, counsel them not to provide for their own life and well-being, or for their children after them.

But how few there have been in any age who have not been afraid of Nature. How few have set them-

selves, like Rarey, to tame her by finding out what she is thinking of. The mass are glad to have the results of science, as they are to buy Mr. Rarey's horses after they are tamed; but for want of courage or of wit, they had rather leave the taming process to someone else. And therefore we may say that what knowledge of Nature we have—and we have very little—we owe to the courage of those men—and they have been very few—who have been inspired to face Nature boldly; and say—or, what is better, act as if they were saying —"I find something in me which I do not find in you; which gives me the hope that I can grow to understand you, though you may not understand me; that I may become your master, and not as now, you mine. And if not, I will know; or die in the search."

It is to those men, the few and far between, in a very few ages and very few countries, who have thus risen in rebellion against Nature, and looked it in the face with an unquailing glance, that we owe what we call Physical Science.

There have been four races—or rather a very few men of each four races—who have faced Nature after this gallant wise.

First, the old Jews. I speak of them, be it remembered, exclusively from an historical, and not a religious point of view.

These people, at a very remote epoch, emerged from a country highly civilised, but sunk in the superstitions of nature-worship. They invaded and mingled with tribes whose superstitions were even more debased, silly, and foul than those of the Egyptians from whom they escaped. Their own masses were for centuries given up to nature-worship. Now, among those

Jews arose men—a very few—sages—prophets—call them what you will, the men were inspired heroes and philosophers—who assumed towards nature an attitude utterly different from the rest of their countrymen and the rest of the then world; who denounced superstition and the dread of nature as the parent of all manner of vice and misery; who for themselves said boldly that they discerned in the universe an order, a unity, a permanence of law, which gave them courage instead of fear. They found delight and not dread in the thought that the universe obeyed a law which could not be broken; that all things continued to that day according to a certain ordinance. They took a view of Nature totally new in that age; healthy, human, cheerful, loving, trustful, and yet reverent—identical with that which happily is beginning to prevail in our own day. They defied those very volcanic and meteoric phenomena of their land, to which their countrymen were slaying their own children in the clefts of the rocks, and, like Theophrastus's superstitious man, pouring their drink-offerings on the smooth stones of the valley; and declared that, for their part, they would not fear, though the earth was moved, and though the hills were carried into the midst of the sea; though the waters raged and swelled, and the mountains shook at the tempest.

The fact is indisputable. And you must pardon me if I express my belief that these men, if they had felt it their business to found a school of inductive physical science, would, owing to that temper of mind, have achieved a very signal success. I ground that opinion on the remarkable, but equally indisputable fact, that no nation has ever succeeded in perpetuating a school

of inductive physical science, save those whose minds have been saturated with this same view of Nature, which they have—as an historic fact—slowly but thoroughly learnt from the writings of these Jewish sages.

Such is the fact. The founders of inductive physical science were not the Jews; but first the Chaldæans, next the Greeks, next their pupils the Romans —or rather a few sages among each race. But what success had they? The Chaldæan astronomers made a few discoveries concerning the motions of the heavenly bodies, which, rudimentary as they were, still prove them to have been men of rare intellect. For a great and a patient genius must he have been, who first distinguished the planets from the fixed stars, or worked out the earliest astronomical calculation. But they seem to have been crushed, as it were, by their own discoveries. They stopped short. They gave way again to the primeval fear of Nature. They sank into planet-worship. They invented, it would seem, that fantastic pseudo-science of astrology, which lay for ages after as an incubus on the human intellect and conscience. They became the magicians and quacks of the old world; and mankind owed them thenceforth nothing but evil. Among the Greeks and Romans, again, those sages who dared face Nature like reasonable men, were accused by the superstitious mob as irreverent impious atheists. The wisest of them all, Socrates, was actually put to death on that charge; and finally, they failed. School after school, in Greece and Rome, struggled to discover, and to get a hearing for, some theory of the universe which was founded on something like experience, reason, common sense. They were not allowed to prosecute

their attempt. The mud-ocean of ignorance and fear in which they struggled so manfully was too strong for them; the mud-waves closed over their heads finally, as the age of the Antonines expired; and the last effort of Græco-Roman thought to explain the universe was Neoplatonism—the muddiest of the muddy—an attempt to apologise for, and organise into a system, all the nature-dreading superstitions of the Roman world. Porphyry, Plotinus, Proclus, poor Hypatia herself, and all her school—they may have had themselves no bodily fear of Nature; for they were noble souls. Yet they spent their time in justifying those who had; in apologising for the superstitions of the very mob which they despised: just as—it sometimes seems to me—some folk in these days are like to end in doing; begging that the masses might be allowed to believe in anything, however false, lest they should believe in nothing at all: as if believing in lies could do anything but harm to any human being. And so died the science of the old world, in a true second childhood, just where it began.

The Jewish sages, I hold, taught that science was probable; the Greeks and Romans proved that it was possible. It remained for our race, under the teaching of both, to bring science into act and fact.

Many causes contributed to give them this power. They were a personally courageous race. This earth has yet seen no braver men than the forefathers of Christian Europe, whether Scandinavian or Teuton, Angle or Frank. They were a practical hard-headed race, with a strong appreciation of facts, and a strong determination to act on them. Their laws, their society, their commerce, their colonisation, their migrations by

land and sea, proved that they were such. They were favoured, moreover, by circumstances, or—as I should rather put it—by that divine Providence which determined their times, and the bounds of their habitation. They came in as the heritors of the decaying civilisation of Greece and Rome; they colonised territories which gave to man special fair play, but no more, in the struggle for existence, the battle with the powers of Nature; tolerably fertile, tolerably temperate; with boundless means of water communication; freer than most parts of the world from those terrible natural phenomena, like the earthquake and the hurricane, before which man lies helpless and astounded, a child beneath the foot of a giant. Nature was to them not so inhospitable as to starve their brains and limbs, as it has done for the Esquimaux or Fuegian; and not so bountiful as to crush them by its very luxuriance, as it has crushed the savages of the tropics. They saw enough of its strength to respect it; not enough to cower before it: and they and it have fought it out; and it seems to me, standing either on London Bridge or on a Holland fen-dyke, that they are winning at last.

But they had a sore battle: a battle against their own fear of the unseen. They brought with them, out of the heart of Asia, dark and sad nature-superstitions, some of which linger among our peasantry till this day, of elves, trolls, nixes, and what not. Their Thor and Odin were at first, probably, only the thunder and the wind: but they had to be appeased in the dark marches of the forest, where hung rotting on the sacred oaks, amid carcases of goat and horse, the carcases of human victims. No one acquainted with the early legends and ballads of our race, but must perceive throughout

them all the prevailing tone of fear and sadness. And to their own superstitions they added those of the Rome which they conquered. They dreaded the Roman she-poisoners and witches, who, like Horace's Canidia, still performed horrid rites in graveyards and dark places of the earth. They dreaded as magical the delicate images engraved on old Greek gems. They dreaded the very Roman cities they had destroyed. They were the work of enchanters. Like the ruins of St. Albans here in England, they were all full of devils, guarding the treasures which the Romans had hidden. The Cæsars became to them magical man-gods. The poet Virgil became the prince of necromancers. If the secrets of Nature were to be known, they were to be known by unlawful means, by prying into the mysteries of the old heathen magicians, or of the Mohammedan doctors of Cordova and Seville; and those who dared to do so were respected and feared, and often came to evil ends. It needed moral courage, then, to face and interpret fact. Such brave men as Pope Gerbert, Roger Bacon, Galileo, even Kepler, did not lead happy lives; some of them found themselves in prison. All the medieval sages—even Albertus Magnus—were stigmatised as magicians. One wonders that more of them did not imitate poor Paracelsus, who, unable to get a hearing for his coarse common sense, took—vain and sensual—to drinking the laudanum which he himself had discovered, and vaunted as a priceless boon to men; and died as the fool dieth, in spite of all his wisdom. For the "Romani nominis umbra," the shadow of the mighty race whom they had conquered, lay heavy on our forefathers for centuries. And their dread of the great heathens was really a

dread of Nature, and of the powers thereof. For when the authority of great names has reigned unquestioned for many centuries, those names become, to the human mind, integral and necessary parts of Nature itself. They are, as it were, absorbed into it; they become its laws, its canons, its demiurges, and guardian spirits; their words become regarded as actual facts; in one word, they become a superstition, and are feared as parts of the vast unknown; and to deny what they have said is, in the minds of the many, not merely to fly in the face of reverent wisdom, but to fly in the face of facts. During a great part of the Middle Ages, for instance, it was impossible for an educated man to think of nature itself, without thinking first of what Aristotle had said of her. Aristotle's dicta were Nature; and when Benedetti, at Venice, opposed in 1585 Aristotle's opinions on violent and natural motion, there were hundreds, perhaps, in the universities of Europe—as there certainly were in the days of the immortal "Epistolæ Obscurorum Virorum"—who were ready, in spite of all Benedetti's professed reverence for Aristotle, to accuse him of outraging not only the father of philosophy, but Nature itself and its palpable and notorious facts. For the restoration of letters in the fifteenth century had not at first mended matters, so strong was the dread of Nature in the minds of the masses. The minds of men had sported forth, not toward any sound investigation of facts, but toward an eclectic resuscitation of Neoplatonism; which endured, not without a certain beauty and use—as let Spenser's "Faërie Queen" bear witness—till the latter half of the seventeenth century.

After that time a rapid change began. It is marked

by—it has been notably assisted by—the foundation of our own Royal Society. Its causes I will not enter into; they are so inextricably mixed, I hold, with theological questions, that they cannot be discussed here. I will only point out to you these facts: that, from the latter part of the seventeenth century, the noblest heads and the noblest hearts of Europe concentrated themselves more and more on the brave and patient investigation of physical facts, as the source of priceless future blessings to mankind; that the eighteenth century which it has been the fashion of late to depreciate, did more for the welfare of mankind, in every conceivable direction, than the whole fifteen centuries before it; that it did this good work by boldly observing and analysing facts; that this boldness towards facts increased in proportion as Europe became indoctrinated with the Jewish literature; and that, notably, such men as Kepler, Newton, Berkeley, Spinoza, Leibnitz, Descartes, in whatsoever else they differed, agreed in this, that their attitude towards Nature was derived from the teaching of the Jewish sages. I believe that we are not yet fully aware how much we owe to the Jewish mind, in the gradual emancipation of the human intellect. The connection may not, of course, be one of cause and effect; it may be a mere coincidence. I believe it to be a cause; one of course of very many causes: but still an integral cause. At least the coincidence is too remarkable a fact not to be worthy of investigation.

I said, just now—The emancipation of the human intellect. I did not say—Of science or of the scientific intellect; and for this reason:

That the emancipation of science is the emancipation

of the common mind of all men. All men can partake of the gains of free scientific thought, not merely by enjoying its physical results, but by becoming more scientific men themselves.

Therefore it was, that though I began my first lecture by defining superstition, I did not begin my second by defining its antagonist, science. For the word "science" defines itself. It means simply knowledge; that is, of course, right knowledge, or such an approximation as can be obtained; knowledge of any natural object, its classification, its causes, its effects; or in plain English, what it is, how it came where it is, and what can be done with it.

And scientific method, likewise, needs no definition; for it is simply the exercise of common sense. It is not a peculiar, unique, professional, or mysterious process of the understanding: but the same which all men employ, from the cradle to the grave, in forming correct conclusions.

Every one who knows the philosophic writings of Mr. John Stuart Mill, will be familiar with this opinion. But to those who have no leisure to study him, I should recommend the reading of Professor Huxley's third lecture on the origin of species.

In that he shows, with great logical skill, as well as with some humour, how the man who, on rising in the morning finds the parlour-window open, the spoons and teapot gone, the mark of a dirty hand on the window-sill, and that of a hob-nailed boot outside, and comes to the conclusion that someone has broken open the window, and stolen the plate, arrives at that hypothesis—for it is nothing more—by a long and complex train of inductions and deductions of just the same

kind as those which, according to the Baconian philosophy, are to be used for investigating the deepest secrets of Nature.

This is true, even of those sciences which involve long mathematical calculations. In fact, the stating of the problem to be solved is the most important element in the calculation; and that is so thoroughly a labour of common sense that an utterly uneducated man may, and often does, state an abstruse problem clearly and correctly; seeing what ought to be proved, and perhaps how to prove it, though he may be unable to work the problem out for want of mathematical knowledge.

But that mathematical knowledge is not—as all Cambridge men are surely aware—the result of any special gift. It is merely the development of those conceptions of form and number which every human being possesses; and any person of average intellect can make himself a fair mathematician if he will only pay continuous attention; in plain English, think enough about the subject.

There are sciences, again, which do not involve mathematical calculation; for instance, botany, zoology, geology, which are just now passing from their old stage of classificatory sciences into the rank of organic ones. These are, without doubt, altogether within the scope of the merest common sense. Any man or woman of average intellect, if they will but observe and think for themselves, freely, boldly, patiently, accurately, may judge for themselves of the conclusions of these sciences, may add to these conclusions fresh and important discoveries; and if I am asked for a proof of what I assert, I point to "Rain and Rivers," written by no professed

scientific man, but by a colonel in the Guards, known to fame only as one of the most perfect horsemen in the world.

Let me illustrate my meaning by an example. A man—I do not say a geologist, but simply a man, squire or ploughman—sees a small valley, say one of the side-glens which open into the larger valleys in the Windsor forest district. He wishes to ascertain its age.

He has, at first sight, a very simple measure—that of denudation. He sees that the glen is now being eaten out by a little stream, the product of innumerable springs which arise along its sides, and which are fed entirely by the rain on the moors above. He finds, on observation, that this stream brings down some ten cubic yards of sand and gravel, on an average, every year. The actual quantity of earth which has been removed to make the glen may be several million cubic yards. Here is an easy sum in arithmetic. At the rate of ten cubic yards a-year, the stream has taken several hundred thousand years to make the glen.

You will observe that this result is obtained by mere common sense. He has a right to assume that the stream originally began the glen, because he finds it in the act of enlarging it; just as much right as he has to assume, if he find a hole in his pocket, and his last coin in the act of falling through it, that the rest of his money has fallen through the same hole. It is a sufficient cause, and the simplest. A number of observations as to the present rate of denudation, and a sum which any railroad contractor can do in his head, to determine the solid contents of the valley, are all

that are needed. The method is that of science: but it is also that of simple common sense. You will remember, therefore, that this is no mere theory or hypothesis, but a pretty fair and simple conclusion from palpable facts; that the probability lies with the belief that the glen is some hundreds of thousands of years old; that it is not the observer's business to prove it further, but other persons' to disprove it, if they can.

But does the matter end here? No. And, for certain reasons, it is good that it should not end here.

The observer, if he be a cautious man, begins to see if he can disprove his own conclusions; moreover, being human, he is probably somewhat awed, if not appalled, by his own conclusion. Hundreds of thousands of years spent in making that little glen! Common sense would say that the longer it took to make, the less wonder there was in its being made at last: but the instinctive human feeling is the opposite. There is in men, and there remains in them, even after they are civilised, and all other forms of the dread of Nature have died out in them, a dread of size, of vast space, of vast time; that latter, mind, being always imagined as space, as we confess when we speak instinctively of a space of time. They will not understand that size is merely a relative, not an absolute, term; that if we were a thousand times larger than we are, the universe would be a thousand times smaller than it is; that if we could think a thousand times faster than we do, time would be a thousand times longer than it is; that there is One in whom we live, and move, and have our being, to whom one day is as a thousand years, and a thousand

years as one day. I believe this dread of size to be merely, like all other superstitions, a result of bodily fear; a development of the instinct which makes a little dog run away from a big dog. Be that as it may, every observer has it; and so the man's conclusion seems to him strange, doubtful: he will reconsider it.

Moreover, if he be an experienced man, he is well aware that first guesses, first hypotheses, are not always the right ones; and if he be a modest man, he will consider the fact that many thousands of thoughtful men in all ages, and many thousands still, would say, that the glen can only be a few thousand, or possibly a few hundred, years old. And he will feel bound to consider their opinion; as far as it is, like his own, drawn from facts, but no further.

So he casts about for all other methods by which the glen may have been produced, to see if any one of them will account for it in a shorter time.

1. Was it made by an earthquake? No; for the strata on both sides are identical, at the same level, and in the same plane.

2. Or by a mighty current? If so, the flood must have run in at the upper end, before it ran out at the lower. But nothing has run in at the upper end. All round above are the undisturbed gravel-beds of the horizontal moor, without channel or depression.

3. Or by water draining off a vast flat as it was upheaved out of the sea? That is a likely guess. The valley at its upper end spreads out like the fingers of a hand, as the gullies in tide-muds do.

But that hypothesis will not stand. There is no vast unbroken flat behind the glen. Right and left of

it are other similar glens, parted from it by long narrow ridges: these also must be explained on the same hypothesis; but they cannot. For there could not have been surface-drainage to make them all, or a tenth of them. There are no other possible hypotheses; and so he must fall back on the original theory—the rain, the springs, the brook; they have done it all, even as they are doing it this day.

But is not that still a hasty assumption? May not their denuding power have been far greater in old times than now?

Why should it? Because there was more rain then than now? That he must put out of court; there is no evidence of it whatsoever.

Because the land was more friable originally? Well, there is a great deal to be said for that. The experience of every countryman tells him that bare or fallow land is more easily washed away than land under vegetation. And no doubt, when these gravels and sands rose from the sea, they were barren for hundreds of years. He has some measure of the time required, because he can tell roughly how long it takes for sands and shingles left by the sea to become covered with vegetation. But he must allow that the friability of the land must have been originally much greater than now, for hundreds of years.

But again, does that fact really cut off any great space of time from his hundreds of thousands of years? For when the land first rose from the sea, that glen was not there. Some slight bay or bend in the shore determined its site. That stream was not there. It was split up into a million little springs, oozing side by side from the shore, and having each a very minute

denuding power, which kept continually increasing by combination as the glen ate its way inwards, and the rainfall drained by all these little springs was collected into the one central stream. So that when the ground being bare was most liable to be denuded, the water was least able to do it; and as the denuding power of the water increased, the land, being covered with vegetation, became more and more able to resist it. All this he has seen, going on at the present day in the similar gullies worn in the soft strata of the South Hampshire coast; especially round Bournemouth.

So the two disturbing elements in the calculation may be fairly set off against each other, as making a difference of only a few thousands or tens of thousands of years either way; and the age of the glen may fairly be, if not a million years, yet such a length of years as mankind still speak of with bated breath, as if forsooth it would do them some harm.

I trust that every scientific man in this room will agree with me, that the imaginary squire or ploughman would have been conducting his investigation strictly according to the laws of the Baconian philosophy. You will remark, meanwhile, that he has not used a single scientific term, or referred to a single scientific investigation; and has observed nothing and thought nothing, which might not have been observed and thought by any one who chose to use his common sense, and not to be afraid.

But because he has come round, after all this further investigation, to something very like his first conclusion, was all that further investigation useless? No—a thousand times, no. It is this very verification of hypotheses which makes the sound ones safe, and destroys the

unsound. It is this struggle with all sorts of superstitions which makes science strong and sure, and her march irresistible, winning ground slowly, but never receding from it. It is this buffeting of adversity which compels her not to rest dangerously upon the shallow sand of first guesses, and single observations; but to strike her roots down, deep, wide, and interlaced, into the solid ground of actual facts.

It is very necessary to insist on this point. For there have been men in all past ages—I do not say whether there are any such now, but I am inclined to think that there will be hereafter—men who have tried to represent scientific method as something difficult, mysterious, peculiar, unique, not to be attained by the unscientific mass; and this not for the purpose of exalting science, but rather of discrediting her. For as long as the masses, educated or uneducated, are ignorant of what scientific method is, they will look on scientific men, as the middle age looked on necromancers, as a privileged, but awful and uncanny caste, possessed of mighty secrets; who may do them great good, but may also do them great harm. Which belief on the part of the masses will enable these persons to instal themselves as the critics of science, though not scientific men themselves: and—as Shakespeare has it—to talk of Robin Hood, though they never shot in his bow. Thus they become mediators to the masses between the scientific and the unscientific worlds. They tell them—You are not to trust the conclusions of men of science at first hand. You are not fit judges of their facts or of their methods. It is we who will, by a cautious eclecticism, choose out for you such of their conclusions as are safe for you;

and them we will advise you to believe. To the scientific man, on the other hand, as often as anything is discovered unpleasing to them, they will say, imperiously and e cathedrâ—Your new theory contradicts the established facts of science. For they will know well that whatever the men of science think of their assertion, the masses will believe it; totally unaware that the speakers are by their very terms showing their ignorance of science; and that what they call established facts scientific men call merely provisional conclusions, which they would throw away to-morrow without a pang were the known facts explained better by a fresh theory, or did fresh facts require one.

This has happened too often. It is in the interest of superstition that it should happen again; and the best way to prevent it surely is to tell the masses—Scientific method is no peculiar mystery, requiring a peculiar initiation. It is simply common sense, combined with uncommon courage, which includes uncommon honesty and uncommon patience; and if you will be brave, honest, patient, and rational, you will need no mystagogues to tell you what in science to believe and what not to believe; for you will be just as good judges of scientific facts and theories as those who assume the right of guiding your convictions. You are men and women: and more than that you need not be.

And let me say that the man of our days whose writings exemplify most thoroughly what I am going to say is the justly revered Mr. Thomas Carlyle.

As far as I know he has never written on any scientific subject. For aught I am aware of, he may know nothing of mathematics or chemistry, of comparative anatomy or geology. For aught I am aware of, he

may know a great deal about them all, and, like a wise man, hold his tongue, and give the world merely the results in the form of general thought. But this I know; that his writings are instinct with the very spirit of science; that he has taught men, more than any living man, the meaning and end of science; that he has taught men moral and intellectual courage; to face facts boldly, while they confess the divineness of facts; not to be afraid of Nature, and not to worship Nature; to believe that man can know truth; and that only in as far as he knows truth can he live worthily on this earth. And thus he has vindicated, as no other man in our days has done, at once the dignity of Nature and the dignity of spirit. That he would have made a distinguished scientific man, we may be as certain from his writings as we may be certain, when we see a fine old horse of a certain stamp, that he would have made a first-class hunter, though he has been unfortunately all his life in harness. Therefore, did I try to train a young man of science to be true, devout, and earnest, accurate and daring, I should say—Read what you will: but at least read Carlyle. It is a small matter to me—and I doubt not to him—whether you will agree with his special conclusions: but his premises and his method are irrefragable; for they stand on the "voluntatem Dei in rebus revelatam"—on fact and common sense.

And Mr. Carlyle's writings, if I am correct in my estimate of them, will afford a very sufficient answer to those who think that the scientific habit of mind tends to irreverence.

Doubtless this accusation will always be brought against science by those who confound reverence with

fear. For from blind fear of the unknown, science does certainly deliver man. She does by man as he does by an unbroken colt. The colt sees by the road side some quite new object—a cast-away boot, an old kettle, or what not. What a fearful monster! What unknown terrific powers may it not possess! And the colt shies across the road, runs up the bank, rears on end; putting itself thereby, as many a man does, in real danger. What cure is there? But one; experience. So science takes us, as we should take the colt, gently by the halter; and makes us simply smell at the new monster; till after a few trembling sniffs, we discover, like the colt, that it is not a monster, but a kettle. Yet I think, if we sum up the loss and gain, we shall find the colt's character has gained, rather than lost, by being thus disabused. He learns to substitute a very rational reverence for the man who is breaking him in, for a totally irrational reverence for the kettle; and becomes thereby a much wiser and more useful member of society, as does the man when disabused of his superstitions.

From which follows one result. That if science proposes—as she does—to make men brave, wise, and independent, she must needs excite unpleasant feelings in all who desire to keep men cowardly, ignorant, and slavish. And that too many such persons have existed in all ages is but too notorious. There have been from all time, goëtai, quacks, powwow men, rain-makers, and necromancers of various sorts, who having for their own purposes set forth partial, ill-grounded, fantastic, and frightful interpretations of nature, have no love for those who search after a true, exact, brave, and hopeful one. And therefore it is to be feared, or hoped,

that science and superstition will to the world's end remain irreconcilable and internecine foes.

Conceive the feelings of an old Lapland witch, who has had for the last fifty years all the winds in a seal-skin bag, and has been selling fair breezes to northern skippers at so much a puff, asserting her powers so often, poor old soul, that she has got to half believe them herself—conceive, I say, her feelings at seeing her customers watch the Admiralty storm-signals, and con the weather reports in *The Times*. Conceive the feelings of Sir Samuel Baker's African friend, Katchiba, the rain-making chief, who possessed a whole houseful of thunder and lightning—though he did not, he confessed, keep it in a bottle as they do in England—if Sir Samuel had had the means, and the will, of giving to Katchiba's Negros a course of lectures on electricity, with appropriate experiments, and a real bottle full of real lightning among the foremost.

It is clear that only two methods of self-defence would have been open to the rain-maker: namely, either to kill Sir Samuel, or to buy his real secret of bottling the lightning, that he might use it for his own ends. The former method—that of killing the man of science—was found more easy in ancient times; the latter in these modern ones. And there have been always those who, too good-natured to kill the scientific man, have patronised knowledge, not for its own sake, but for the use which may be made of it; who would like to keep a tame man of science, as they would a tame poet, or a tame parrot; who say—Let us have science by all means, but not too much of it. It is a dangerous thing; to be doled out to the world, like medicine, in small and cautious doses. You, the scientific man,

will of course freely discover what you choose. Only do not talk too loudly about it: leave that to us. We understand the world, and are meant to guide and govern it. So discover freely: and meanwhile hand over your discoveries to us, that we may instruct and edify the populace with so much of them as we think safe, while we keep our position thereby, and in many cases make much money by your science. Do that, and we will patronise you, applaud you, ask you to our houses; and you shall be clothed in purple and fine linen, and fare sumptuously with us every day. I know not whether these latter are not the worst enemies which science has. They are often such excellent, respectable, orderly, well-meaning persons. They desire so sincerely that everyone should be wise: only not too wise. They are so utterly unaware of the mischief they are doing. They would recoil with horror if they were told they were so many Iscariots, betraying Truth with a kiss.

But science, as yet, has withstood both terrors and blandishments. In old times she endured being imprisoned and slain. She came to life again. Perhaps it was the will of Him in whom all things live, that she should live. Perhaps it was His spirit which gave her life.

She can endure, too, being starved. Her votaries have not as yet cared much for purple and fine linen, and sumptuous fare. There are a very few among them who, joining brilliant talents to solid learning, have risen to deserved popularity, to titles, and to wealth. But even their labours, it seems to me, are never rewarded in any proportion to the time and the intellect spent on them, nor to the benefits which they

bring to mankind; while the great majority, unpaid and unknown, toil on, and have to find in science her own reward. Better, perhaps, that it should be so. Better for science that she should be free, in holy poverty, to go where she will and say what she knows, than that she should be hired out at so much a year to say things pleasing to the many, and to those who guide the many. And so, I verily believe, the majority of scientific men think. There are those among them who have obeyed very faithfully St. Paul's precept: "No man that warreth entangleth himself with the affairs of this life." For they have discovered that they are engaged in a war—a veritable war—against the rulers of darkness, against ignorance and its twin children, fear and cruelty. Of that war they see neither the end nor even the plan. But they are ready to go on; ready, with Socrates, "to follow reason whithersoever it leads;" and content, meanwhile, like good soldiers in a campaign, if they can keep tolerably in a line, and use their weapons, and see a few yards ahead of them through the smoke and the woods. They will come out somewhere at last; they know not where nor when: but they will come out at last, into the daylight and the open field; and be told then—perhaps to their own astonishment—as many a gallant soldier has been told, that by simply walking straight on, and doing the duty which lay nearest them, they have helped to win a great battle, and slay great giants, earning the thanks of their country and of mankind.

And, meanwhile, if they get their shilling a-day of fighting-pay, they are content. I had almost said, they ought to be content. For science is, I verily believe,

like virtue, its own exceeding great reward. I can conceive few human states more enviable than that of the man to whom, panting in the foul laboratory, or watching for his life under the tropic forest, Isis shall for a moment lift her sacred veil, and show him, once and for ever, the thing he dreamed not of; some law, or even mere hint of a law, explaining one fact; but explaining with it a thousand more, connecting them all with each other and with the mighty whole, till order and meaning shoots through some old Chaos of scattered observations.

Is not that a joy, a prize, which wealth cannot give, nor poverty take away? What it may lead to, he knows not. Of what use it may become, he knows not. But this he knows, that somewhere it must lead; of some use it will be. For it is a truth; and having found a truth, he has exorcised one more of the ghosts which haunt humanity. He has left one object less for man to fear; one object more for man to use. Yes, the scientific man may have this comfort, that whatever he has done, he has done good; that he is following a mistress who has never yet conferred aught but benefits on the human race.

What physical science may do hereafter I know not; but as yet she has done this:

She has enormously increased the wealth of the human race; and has therefore given employment, food, existence, to millions who, without science, would either have starved or have never been born. She has shown that the dictum of the early political economists, that population has a tendency to increase faster than the means of subsistence, is no law of humanity, but merely a tendency of the barbaric and

ignorant man, which can be counteracted by increasing manifold by scientific means his powers of producing food. She has taught men, during the last few years, to foresee and elude the most destructive storms; and there is no reason for doubting, and many reasons for hoping, that she will gradually teach men to elude other terrific forces of nature, too powerful and too seemingly capricious for them to conquer. She has discovered innumerable remedies and alleviations for pains and disease. She has thrown such light on the causes of epidemics, that we are able to say now that the presence of cholera—and probably of all zymotic diseases—in any place, is usually a sin and a shame, for which the owners and authorities of that place ought to be punishable by law, as destroyers of their fellow-men; while for the weak, for those who, in the barbarous and semi-barbarous state—and out of that last we are only just emerging—how much has she done; an earnest of much more which she will do? She has delivered the insane—I may say by the scientific insight of one man, more worthy of titles and pensions than nine-tenths of those who earn them—I mean the great and good Pinel—from hopeless misery and torture into comparative peace and comfort, and at least the possibility of cure. For children, she has done much, or rather might do, would parents read and perpend such books as Andrew Combe's and those of other writers on physical education. We should not then see the children, even of the rich, done to death piecemeal by improper food, improper clothes, neglect of ventilation and the commonest measures for preserving health. We should not see their intellects stunted by Procrustean attempts to teach them all the same accom-

plishments, to the neglect, most often, of any sound practical training of their faculties. We should not see slight indigestion, or temporary rushes of blood to the head, condemned and punished as sins against Him who took up little children in His arms and blessed them.

But we may have hope. When we compare education now with what it was even forty years ago, much more with the stupid brutality of the monastic system, we may hail for children, as well as for grown people, the advent of the reign of common sense.

And for woman—What might I not say on that point? But most of it would be fitly discussed only among physicians and biologists: here I will say only this: Science has exterminated, at least among civilised nations, witch-manias. Women—at least white women—are no longer tortured or burnt alive from man's blind fear of the unknown. If science had done no more than that, she would deserve the perpetual thanks and the perpetual trust, not only of the women whom she has preserved from agony, but the men whom she has preserved from crime.

These benefits have already accrued to civilised men, because they have lately allowed a very few of their number peaceably to imitate Mr. Rarey, and find out what nature—or rather, to speak at once reverently and accurately, He who made nature—is thinking of; and obey the "voluntatem Dei in rebus revelatam." This science has done, while yet in her infancy. What she will do in her maturity, who dare predict? At least, in the face of such facts as these, those who bid us fear, or restrain, or mutilate science, bid us commit an act of folly, as well as of ingratitude, which can

only harm ourselves. For science has as yet done nothing but good. Will any one tell me what harm it has ever done? When any one will show me a single result of science, of the knowledge of and use of physical facts, which has not tended directly to the benefit of mankind, moral and spiritual, as well as physical and economic—then I shall be tempted to believe that Solomon was wrong when he said that the one thing to be sought after on earth, more precious than all treasure, she who has length of days in her right hand, and in her left hand riches and honour, whose ways are ways of pleasantness and all her paths are peace, who is a tree of life to all who lay hold on her, and makes happy every one who retains her, is—as you will see if you will yourselves consult the passage—that very Wisdom—by which God has founded the earth; and that very Understanding—by which He has established the heavens.

THOUGHTS IN A GRAVEL-PIT.

THOUGHTS IN A GRAVEL-PIT.*

LADIES AND GENTLEMEN, we may of course think of anything which we choose in a gravel-pit, as we may anywhere else. Thought is free: at least so we fancy.

But the most right sort of thought, after all, is thought about what lies nearest us; not always, but surely once in a way, that we may understand something of everyday objects. And therefore it may be well worth our while to go once into a gravel-pit, and think about it, till we have learnt what a gravel-pit is.

Learnt what a gravel-pit is? Everybody knows.

If it be so, everybody knows more than I know. We all know a gravel-pit when we see one; but we do not all know what we see. I do not know. I know a little; a few scraps of fact about these pits round here, though about no others. Were I to go into a pit a hundred miles, even fifty miles off, I could tell you nothing certain about it; perhaps might make a dozen mistakes. But what I know, with tolerable

* A Lecture delivered at the Mechanics' Institute, Odiham, 1857.

certainty, about the pits round here, I wish to tell you to-night.

But why? You do not need, one in ten of you, to know anything about gravel, unless you be highway surveyor, or have a garden-walk to make; and then someone will easily tell you where the best gravel is to be got, at so much a load.

Very true; but you come here to-night to instruct yourselves; that is, to learn, if you can, something more about the world you live in; something more about God who made the world.

And you come here to educate yourselves; to educe and bring out your own powers of perceiving, judging, reasoning; to improve yourselves in the art of all arts, which is, the art of learning. That is mental education.

Now if a gravel-pit will teach you a little about these things, you will surely call it a rich gravel-pit. If it helps you to wisdom, which is worth more than gold; which is the only way to get gold wisely, and spend it wisely; then we will call our pit no more a gravel-pit, but a wisdom-pit, a mine of wisdom.

Let us go out, then, in fancy (for it is too cold to go out in person) to Hook Common, scramble down into the first gravel-pit we come to, and see what we can see.

The first thing we see is a quantity of stones, more or less rounded, lying in gravel and poor clay.

Well—what do those stones tell us?

These stones, as I told you when I addressed you last, are ancient and venerable worthies. They have seen a great deal in their time. They have had a great deal of knocking about, and have stood it

manfully. They have stood the knocking about of three worlds already; and have done their duty therein; and they are ready (if you choose to mend the road with them) to stand the knocking about of this fourth world, and being most excellent gravel, to do their duty in this world likewise; which is more, I fear, than either you or I can say for ourselves.

Three worlds?

Yes. Standing there in the gravel-pit, I see three old worlds, in each of which these stones played their part; and this world of man for the fourth, and the best of all—for man if not for the stones. I speak sober truth. Let me explain it step by step.

You know the chalk-hills to the south; and the sands of Crooksbury and the Hind Head beyond them. There is one world.

You know the clays and sands of Hook and Newnham, Dogmersfield and Shapley Heath, and all the country to the north as far as Reading. There is a second world.

You know the gravel-pit itself; and all the upper soils and gravels, which are spread over the length and breadth of the country to the north. There is a third world.

Let us take them one by one.

First, the chalk.

The chalk-hills rise much higher than the surrounding country; but you must not therefore suppose that they were made after it, and laid on the top of it. That guess would be true, if you went south-east from here toward the Hind Head. The chalk lies on the top of the sands of Crooksbury Hill, and the clays of Holt Forest; but it dips underneath the sands of Shapley

Heath, and the clays of Dogmersfield, and reappears from underneath them again at Reading.

Thus you at Odiham stand on the edge of a chalk basin; of what was once a sea, or estuary, with shores of chalk, which begins at the foot of the High Clere Hills, and runs eastward, widening as it goes, past London, into the Eastern Sea. Everywhere under this great basin is the floor of chalk, covered with clays and sands, which, for certain reasons, are called by geologists Tertiary strata.

But what has this to do with a gravel-pit?

This first. That all the flints in this pit have come out of the chalk. They are coloured, most of them, with iron, which has turned them brown; but they are exactly the same flints as those gray ones in the chalk-pit on the other side of the town.

How do I know that?

I think our own eyes will prove it: they are the same shapes, and of the same substance; but as a still surer proof, we find exactly the same fossils in them; sponges, choanites (which were something like our modern sea-anemones), corals, and "shepherds' crowns" as the boys call the fossil sea-urchins. The species of all these, and of other fossils, in the chalk-pit and in the gravel-pit, are absolutely identical. The natural conclusion is, then, that the gravel has been formed from the washings of the chalk. The white lime of the chalk has been carried away in water by some flood or floods; the heavier flints have been left behind.

Stop now one moment, and think. You all know how very few flints there are in the chalk-pit, in proportion to the mass of chalk. You all know what vast

gravel-beds cover the country to the north, and often to the thickness of many feet. Try and conceive, then, what a much more vast mass of chalk must have been washed away, to leave that vast mass of gravel behind it.—Conceive? It is past conception. I will but give you two hints as to its probable size.

The chalk to the eastward, between here and Farnham, is a far narrower and shallower band than anywhere else in England. Its narrowest point is, I believe, beneath the bishop's palace at Farnham, where it may be a hundred feet thick, instead of several hundred, as it usually is in other parts of England. The cause of this is, that the whole of the upper chalk has been washed away, to form the gravel-beds to the north and east of us.

Again. Some of you may have been on the Hind Head or on Leith Hill, and have looked southward over the glorious prospect of the rich Weald, spread out five hundred feet below—a sight to make an Englishman proud of his native land. Now, the mass of chalk which has been carried away began behind you, at the Hogsback, and the line of chalk-hills which runs to Boxhill, and stretched hundreds of feet above your head as you stand on Hind Head or Leith Hill, right over the old Weald of Sussex to the chalk of the South Downs. And out of the scourings of that vast mass of chalk was our gravel-pit made.

Of that, and also of the Hind Head sands below it.

For you will find a great deal of sharp sand in our gravel-pits, which has not, I believe, come from the grinding of chalk flints; for if it had been ground, it would not be the sharp sand it is; the particles would be rounded off at the edges. This is probably sand

from the Hind Head; from what geologists term the greensands, below the chalk.

And I have a better proof of this—at least I should have in every gravel-pit at Eversley—in a few pieces of a stone which is not chalk-flint at all; flattish and oblong, not more than two or three inches in diameter; of a grayish colour, and a porous worm-eaten surface, which no chalk-flint ever has. They are chert, which abound in the greensand formation; and insignificant as they look, are a great token of a most important fact; that the currents which formed our sands and gravels set from the south during a long series of ages, first till they had washed away all the chalk off the Weald, and next till they had washed away a great part of the sands, which then became exposed, the remains whereof form great commons over a wide tract of Surrey.

Now let me pause, and ask you to observe one thing. How, in inductive science, we arrive, by patient and simple observation of the things around us, at the most grand and surprising results. Of course I am not giving you the whole of the facts which have made this argument certain. I am only giving you enough to make it probable to you. Its certainty has been proved by many different men, labouring in many different parts of England, and of the Continent also, and then comparing their discoveries together; often, of course, making mistakes; but each working on patiently, and correcting their early mistakes by fresh facts, till they have at last got hold of the true key to the mystery, and are as certain of the existence of the great island of the Weald, and its gradual destruction by the waves and currents of an ancient sea, as if they

had seen it with their bodily eyes. You must take all this, of course, as truth from me to-night; but you may go and examine for yourselves; and see how far your own common sense and observations agree with those of learned geologists.

The history of this great Wealden island to the south-east of us is obscure enough; but a few general facts, which bear upon our gravel-pit, I can give you.

I must begin, however, ages before the Wealden island existed; when the chalk of which its mass was composed was at the bottom of a deep ocean.

We know now what chalk is, and how it was made. We know that it was deposited as white lime mud, at a vast sea-depth, seemingly undisturbed by winds or currents. We know that not only the flint, but the chalk itself, is made up of shells; the shell of little microscopic animalcules smaller than a needle's point, in millions of millions, some whole, some broken, some in powder, which lived, and died, and decayed for ages in the great chalk sea.

We know this, I say. We had suspected it long ago, and become more and more certain of it as the years went on. But now we seem to have a proof of it which is past gainsaying.

In the late survey of the bottom of the Atlantic Ocean, with a view to laying down the electric telegraph between England and America, by Lieutenant Maury of the American navy, a great discovery was made. It was found that the floor of the Atlantic Ocean, after you have left the land a few hundred miles, is one vast plain of mud, of some thirteen hundred miles in breadth. But here is the wonder;

it was found that at a depth averaging 1,600 fathoms —9,600 feet—in utter darkness, the sea floor is covered with countless millions of animalcule-shells, of the same families, though not of the same species, as those which compose the chalk.

At the bottom of a still ocean, then, the chalk was deposited. But it took many an age to raise it to where Odiham chalk-pit now stands.

But how was it raised?

By the upheaving force of earthquakes. Or rather, by the upheaving force which causes earthquakes, when it acts in a single shock, cracking the earth's crust by an explosion; but which acts, too, slowly and quietly, uplifting day by day, and year by year, some portions of the earth's surface, and letting others sink down; as in the case of the valley of the Jordan and the Dead Sea, which is now 1,300 feet below the level of the Mediterranean.

That these upheaving forces were much more violent than now, in the earlier epochs of our planet, we have some reason to believe: but the subject is too long a one to enter on now; and all I can say is, that you must conceive for yourself the chalk gradually brought up to the surface, worn away along a shifting shore-line by the waves of the sea, and covered in shallow water by the clays and sands on which Odiham stands; and which compose the earliest part of our second world.

A second world; a new world. We can use no weaker expression. When we compare the chalk with the strata which lie upon it, we can only call them a complete new creation.

For not only were they deposited in shallow water;

a great deal of them, probably, near river-mouths, and by the force of violent currents, as the irregularity of their lower bed proves: but there is hardly a plant or animal found in the chalk itself, which is found in the gravels, sands, or clays above it. The shells are all new species; unseen before in this planet. The vegetables, as far as we know them, are all different from anything found in the chalk, or in the beds below it. God Almighty, for His own good pleasure, has made all things new. It is a very awful fact; but it is a very certain one. Several times, in the history of our planet, has the Lord God fulfilled the words of the Psalmist:

"Thou takest away their breath, they die, and return again to their dust.

"Thou sendest forth thy breath, they are made: and thou renewest the face of the earth."

But in no instance, perhaps, is the gulf so vast; is the leap from one world to another so sheer, as that between the chalk and the London clay above it.

But how do I know that there was a shore-line here? And how do I know that the chalk was covered with sand-beds?

I know that there was a shore-line here, from this fact. If you will look at the surface of the chalk, where the sands and clays lie on it, you will find that it is not smooth; that the beds do not rest conformably on each other, as if they had been laid down quietly by successive tides, while the chalk below was still soft mud. So far from it, the chalk must have become hard rock, and have been exposed to the action of the sea waves, for centuries, perhaps, before the sands began to cover it. For you find the surface of

the chalk furrowed, worn into deep pits, which are often filled with sand, and gravel, and rounded lumps of chalk. You may see this for yourselves, in the topmost layer of any chalk-pit round here. You may see, even, in some places, the holes which boring shells, such as work now close to the tide-level, have made in it; all the signs, in fact, of the chalk having been a rocky sea-beach for ages.

The first bed which you will generally find upon the water-worn surface of the chalk is a layer of green-sand and green-coated flints. Among these are met with in many places beds of a great oyster, now unknown in life. I cannot say whether there are any here; but at Reading, to the east of Farnham, at Croydon, and under London, they are abundant. There must have been miles and miles of oyster-bed at the bottom of that Eocene sea; among the oyster-beds, beds of a peculiar pebble, which we shall see in our gravel-pit.

They are flints; but very small, dark, often almost black, and quite round and polished. Compare them with the average flints of the pit, and you see that while the average flints are fresh from the chalk, these have plainly been rolled and rounded for years. They are (except in their dark colour) exactly such shingle as forms the south-coast beach about Hastings and Brighton. They are the shingle beaches of the Eocene sea, part of which are preserved under the London clay. To the north a vast bed of them remains in its original place, on Blackheath near London; while part, in the district to the south, which the London clay has not covered, have been washed away, and carried into our

gravel-pit, to mingle with other flints fresh from the chalk.

I said just now that I had proof that a great tract of the chalk-hills which are now bare, was once covered with sand and gravel. Here, in the presence of these dark pebbles, is a proof. But I have another, and a yet more curious one.

For our gravel-pit, if it be, will possibly yield us another, and a more curious object. You most of you have seen, I dare say, large stones, several feet long, taken out of these pits. In the gravels and sands at Pirbright they are so plentiful that they are quarried for building-stone. And good building-stone they make; being exceedingly hard, so that no weather will wear them away. They are what is called saccharine (that is, sugary) sandstone. If you chip off a bit, you find it exactly like fine whity-brown sugar, only intensely hard. Now these stones have become very famous; for two reasons. First, the old Druids used them to build their temples. Second, it is a most puzzling question where they came from.

First. They were used to build Druid temples.

If you go to the further lodge of Dogmersfield Park, which opens close to the Barley-mow Inn, you will see there several of them, about five feet high each, set up on end. They run in a line through the plantation past the lodge, along the park palings; one or two are in an adjoining field. They are the remains of a double line; an avenue of stones, which has formed part of an ancient British temple.

I know no more than that: of that I am certain.

But if you go to the Chalk Downs of Wiltshire,

you see these temples in their true grandeur. You have all heard of Stonehenge on Salisbury Plain. Some of you may have heard of the great Druid temple at Abury in Wilts, which, were it not all but destroyed, would be even grander than Stonehenge. These are made of this same sugar-sandstone.

But where did the sandstone come from? You may say, it "grew" of itself in our sands and gravels; but it certainly did not "grow" on the top of a bare chalk down. The Druids must have brought the stones thither, then, from neighbouring gravel-pits. They brought them, no doubt: but not from gravel-pits. The stones are found loose on the downs on the top of the bare chalk, in places where they plainly have not been put by man.

For instance, near Marlborough is a long valley in the chalk, which, for perhaps half a mile, is full of huge blocks of this sandstone, lying about on the turf. The "gray wethers," the shepherds call them. One look at them would show you that no man's hand had put them there. They look like a river of stone, if I may so speak; as if some mighty flood had rolled them along down the valley, and there left them behind as it sunk.

Now, whence did they come?

Many answers have been given to that question. It was supposed by many learned men that they had been brought from the sandstone mountains of Wales, like the rolled pebbles of which I spoke just now. But the answer to that was, that these great stones are not rolled: they are all squarish, more or less; their edges are often sharp and fresh, instead of being polished almost into balls, as they would have been in

rolling two hundred miles along a sea-bottom, before such a tremendous current as would have been needed to carry them.

Then rose a very clever guess. They must have been carried by icebergs, as much silt and stones (we know) has been carried, and have dropped, like them, to the bottom, when the icebergs melted.

There is great reason in that; but we have cause now to be certain that they did not come from Wales. That they are not pieces of a rock older than the chalk, but much younger; that they were very probably formed close to where they now lie.

Now—how do we know that?

If you are not tired with all this close reasoning, I will tell you.—If you are, say so: but as I said at first, I want to show you what steady and sharp head-work this same geology requires, even in the nearest gravel-pit.

Well, then. I do not think our gravel-pit will tell us what we want: but I know one which will.

You have all heard of Lady Grenville's lovely place, Dropmore, beyond Maidenhead; where the taste of that good and great man, the late Lord Grenville, converted into a paradise of landscape-gardening art a barren common, full of clay and gravel-pits. Lord Grenville wanted stones for rockwork; in those pits he found some blocks, of the same substance as those of Stonehenge or Pirbright. And they contain the answer. The upper surface of most of them is the usual clear sugar-sandstone: but the under surface of many has round pebbles imbedded in it, looking just like plums in a pudding; the smaller above and the larger below, as if they had sunk slowly through

the fluid sand, before the whole mass froze, as it were, suddenly together. And these pebbles are nothing else than rolled chalk flints.

That settles the matter. The pebbles could not come from Wales; there are no flints there. They could not have been made before the chalk; for out of the chalk they came; and the only explanation which is left to us, I believe, is, that over the tops of the chalk downs; over our heads where we stand now, there once stretched layers of sand and gravel, "Tertiary strata," as I have been calling them to you; and among them layers of this same hard sandstone.

When the floods came they must have swept away all these soft sands and gravels (possibly to make the Bagshot sands, of which I shall speak presently), and left the chalk downs bare; but while they had strength to move the finer particles, they had not generally strength to move these sandstone blocks, but let them drop through, and remain upon the freshly-bared floor of chalk, as the only relics of a tertiary land long since swept away; while some were carried off, possibly by icebergs, as far as Pirbright, and dropped, as the icebergs melted, both there, at Dogmersfield, and also, though few and small, in Eversley and the neighbourhood.

But how came these tertiary sandstones to be so very hard, while the strata around them are so soft?

Ladies and gentlemen, I know no more than you. Experience seems to say that stone will not harden into that sugary crystalline state, save under the influence of great heat: but I do not know how the heat should have got to that layer in particular. Possibly there may have been eruptions of steam, of boiling

water holding silex (flint) in solution—a very rare occurrence: but something similar is still going on in the famous Geysers or boiling springs of Iceland. However, I have no proof that this was the cause. I suppose we shall find out some day how it happened; for we must never despair of finding out anything which depends on facts.

Part of the town of Odiham, and of North Warnborough, stands, I believe, upon these lower beds, which are called by geologists the Woolwich and Reading beds, and the Plastic clays, from the good brick earth which is so often found among them. But as soon as you get to Hook Common, and to Dogmersfield Park, you enter on a fresh deposit; the great bed of the London clay.

I give you a rough section, from a deep well at Dogmersfield House; from which you may see how steeply the chalk dips down here under the clay, so that Odiham stands, as it were, on the chalk beach of the clay sea.

In boring that well there were pierced:

Forty feet of the upper sands (the Bagshot sands), of which I shall speak presently.

Three hundred and thirty feet of London clay.

Then about forty feet of mottled clays and sands.

Whether the chalk was then reached, I do not know. It must have been close below. But these mottled clays and sands abound in water (being indeed the layer which supplies the great breweries in London, and those soda-water bottles on dumb-waiters which squirt in Trafalgar Square); and (I suppose) the water being reached, the boring ceased.

Now, this great bed of London clay, even more

than the sands below it, deserves the title of a new creation.

As a proof—some of you may recollect, when the South-Western Railway was in making, seeing shells —some of them large and handsome ones—Nautili, taken out of the London clay cutting near Winchfield.

Nautili similar to them (but not the same) are now only found in the hottest parts of the Indian seas; and what is more, not one of those shells is the same as the shells you find in the chalk. Throughout this great bed of London clay, the shells, the remains of plants and animals, are altogether a new creation. If you look carefully at the London clay shells, you will be struck with their general likeness to fresh East Indian shells; and rightly so. They do approach our modern live shells in form, far more than any which preceded them; and indeed, a few of the London clay shells exist still in foreign seas; in the beds, again, above the clay, you will meet with still more species which are yet alive; while in the chalk, and below the chalk, you never meet, I believe, with a single recent shell. It is for this reason that the London clay is said to be Eocene, that is, the dawn of the new creation.

The chalk, I told you, seems to have been deposited at the bottom of a still and deep ocean. But the London clay, we shall find, was deposited in a comparatively shallow sea, least in depth toward High Clere on the west, and deepening towards London and the mouth of the Thames.

For not only is the clay deeper as you travel eastward, but—and this is a matter to which geologists attach great importance—the character of the shells differs in different parts of the clay.

You must know that certain sorts of shells live in deep water, and certain in shallow. You may prove this to yourselves, on a small scale, whenever you go to the seaside. You will find that the shell which crawl on the rocks about high-water mark are different from those which you find at low-tide mark; and those again different from the shells which are brought up by the oyster-dredgers from the sea outside. Now, the lower part of the clay, near here, contains shallow-water shells: but if you went forty miles to the eastward, you would find in the corresponding lower beds of the clay, deep-water shells, and far above them, shallow-water shells such as you find here: a fact which shows plainly that this end of the clay sea was shallowest, and therefore first filled up.

But again—and this is a very curious fact—between the time of the Plastic clays and sands, with their oyster-beds and black pebbles, and that of the London clay, great changes had taken place. The Plastic clay and sands were deposited during a period of earthquake, of upheaval and subsidence of ancient lands; and therefore of violent currents and flood waves, seemingly rushing down from, or round the shores of that Wealden island to the south of us, on the shore of which island Odiham once stood. We know this from the great irregularity of the beds: while the absence of that irregularity proves to us that the London clay was deposited in a quiet sea.

But more. A great change in the climate of this country had taken place meanwhile; slowly perhaps: but still it had taken place.

In the lowest clay above the chalk are found at Reading many leaves, and buds, and seeds of trees,

showing that there was dry land near; and these trees, as far as the best botanists can guess, were trees like those we have in England now. Not of the same species, of course: but still trees belonging to a temperate climate, which had its regular warm summer and cold winter.

But before the London clay had been all deposited, this temperate climate had changed to a tropical one; and the plants and animals of the upper part of the London clay had begun to resemble rather those of the mouths of the African slave-rivers.

Extraordinary as this is, it is certainly true.

We know that the country near the mouth of the Thames, and probably the land round us here, was low rich soil, some half under water, some overflowed by rivers; some by fresh or brackish pools. We know all this; for we find the shells which belong to a shallow sea, mixed with fresh-water ones. We know, too, that the climate of this rich lowland was a tropical one. We know that the neighbourhood of the Isle of Sheppey, at the mouth of the Thames, was covered with rich tropic vegetation; with screw pines and acacias, canes and gourds, tenanted by opossums, bats, and vultures: that huge snakes twined themselves along the ground, tortoises dived in the pools, and crocodiles basked on the muds, while the neighbouring seas swarmed with sharks as huge and terrible as those of a West Indian shore.

It is all very wonderful, ladies and gentlemen: but so it is: and all we can say is, with the Mussulman—"God is great."

And then—when, none knows but God—there came

a time in which some convulsion of nature changed the course of the sea currents, and probably destroyed a vast tract of land between England and France, and probably also, that sunken island of Atlantis of which old Plato dreamed—the vast tract which connected for ages Ireland, Cornwall, Brittany, and Portugal. That convulsion covered up the rich clays with those barren sands and gravels, which now rise in flat and dreary steppes, on the Beacon Hill, Aldershot Moors, Hartford Bridge Flat, Frimley ridges, and Windsor Forest. That rich old world was all swept away, and instead of it desolation and barrenness, piling up slowly on its ruins a desert of sand and shingle, rising inch by inch out of a lifeless sea. There is something very awful to me in the barrenness of those Bagshot sands, after the rich tropic life of the London clay. Not a fossil is to be found in them for miles. Save a few shells, I believe, near Pirbright, there is not a hint that a living being inhabited that doleful sea.

But do not suppose, gentlemen and ladies, that we have yet got our gravel-pit made, or that the way-worn pebbles of which it is composed are near the end of their weary journey. Poor old stones! Driven out of their native chalk, rolled for ages on a sea-beach, they have tried to get a few centuries' sleep in the Eocene sands on the top of the chalk hills behind us, while the London clay was being deposited peacefully in the tropic sea below; and behold, they are swept out, once more, and hurled pell-mell upon the clay, two hundred feet over our heads.

Over our heads, remember. We have come now to a time when Hartford Bridge Flats stretched away to

the Beacon Hill, and many a mile to the south-eastward—even down into Kent, and stretched also over Winchfield and Dogmersfield hither.

What broke them up? What furrowed out their steep side-valleys? What formed the magnificent escarpment of the Beacon Hill, or the lesser one of Finchamstead Ridges? What swept away all but a thin cap of them on the upper part of Dogmersfield Park, another under Winchfield House; another at Bearwood, and so forth?

The convulsions of a third world; more fertile in animal life than those which preceded it: but also, more terrible and rapid, if possible, in its changes.

Of this third world, the one which (so to speak) immediately preceded our own, we know little yet. Its changes are so complicated that geologists have as yet hardly arranged them. But what we can see, I will sketch for you shortly.

A great continent to the south—England, probably an island at the beginning of the period, united to the continent by new beds—the Mammoth ranging up to where we now stand.

Then a period of upheaval. The German Ocean becomes dry land. The Thames, a far larger river than now, runs far eastward to join the Seine, and the Rhine, and other rivers, which altogether flow northward, in one enormous stream, toward the open sea between Scotland and Norway.

And with this, a new creation of enormous quadrupeds, as yet unknown. Countless herds of elephants pastured by the side of that mighty river, where now the Norfolk fisherman dredges their teeth and bones far out in open sea. The hippopotamus floundered in

the Severn, the rhinoceros ranged over the south-western counties; enormous elk and oxen, of species now extinct, inhabited the vast fir and larch forests which stretched from Norfolk to the farthest part of Wales; hyenas and bears double the size of our modern ones, and here and there the sabre-toothed tiger, now extinct, prowled out of the caverns in the limestone hills, to seek their bulky prey.

We see, too, a period—whether the same as this, or after it, I know not yet—in which the mountains of Wales and Cumberland rose to the limits of eternal frost, and Snowdon was indeed Snowdon, an alp down whose valleys vast glaciers spread far and wide; while the reindeer of Lapland, the marmot of the Alps, and the musk ox of Hudson's Bay, fed upon alpine plants, a few of whose descendants still survive, as tokens of the long past age of ice. And at every successive upheaval of the western mountains the displaced waters of the ocean swept over the lower lands, filling the valley of the Thames and of the Wey with vast beds of drift gravel, containing among its chalk flints, fragments of stone from every rock between here and Wales, teeth of elephants, skulls of ox and musk ox; while icebergs, breaking away from the glaciers of the Welsh Alps, sailed down over the spot where we now are, dropping their imbedded stones and silt, to confuse more utterly than before the records of a world rocking and throbbing above the shocks of the nether fire.

At last the convulsions get weak. The German Ocean becomes sea once more; the north-western Alps sink again to a level far lower even than their present one; only to rise again, but not so high as before;

sea-beaches and sea-shells fill many of our lower valleys; whales by hundreds are stranded (as in the Farnham vale) where is now dry land. Gradually the sunken land begins to rise again, and falls perhaps again, and rises again after that, more and more gently each time, till as it were the panting earth, worn out with the fierce passions of her fiery youth, has sobbed herself to sleep once more, and this new world of man is made. And among it, I know not when, or by what diluvial wave out of hundreds which swept the Pleistocene earth, was deposited our little gravel-pit, from which we started on our journey through three worlds.

When?

Enough for us that He knows when, in whose hand are the times and the seasons—God the Father of the spirits of all flesh.

And now, ladies and gentlemen, take from hence a lesson. I have brought you a long and a strange road. Starting from this seemingly uninteresting pit, we have come upon the records of three older worlds, and on hints of worlds far older yet. We have come to them by no theories, no dreams of the fancy, but by plain honest reasoning, from plain honest facts. That wonderful things had happened, we could see: but why they had happened, we saw not. When we began to ask the reason of this thing or of that, remember how we had to stop, and laying our hands upon our mouths, only say with the Mussulman: "God is great." We pick our steps, by lanthorn light indeed, and slowly, but still surely and safely, along a dark and difficult road: but just as we are beginning to pride ourselves on having found our way so cleverly, we come to an

edge of darkness; and see before our feet a bottomless abyss, down which our feeble lanthorn will not throw its light a yard.

Such is true science. Is it a study to make men conceited and self-sufficient? Believe it not. If a scientific man, or one who calls himself so, be conceited, the conceit was there before the science; part of his natural defects: and if it stays there long after he has really given himself to the patient study of nature, then is he one of those of whom Solomon has said: "Though you pound a fool in a mortar among wheat with a pestle, yet will not his folly depart from him."

For what more fit to knock the conceit out of a student, than being pounded by these same hard facts —which tell him just enough to let him know—how little he knows? What more fit to make a man patient, humble, reverent, than being stopped short, as every man of science is, after each half-dozen steps, by some tremendous riddle which he cannot explain—which he may have to wait years to get explained—which as far as he can see will never be explained at all?

The poet says: "An undevout astronomer is mad," and he says truth. It is only those who know a little of nature, who fancy that they know much. I have heard a young man say, after hearing a few popular chemical lectures, and seeing a few bottle and squirt experiments: Oh, water—water is only oxygen and hydrogen!—as if he knew all about it. While the true chemist would smile sadly enough at the youth's hasty conceit, and say in his heart: "Well, he is a lucky fellow. If he knows all about it, it is more

than I do. I don't know what oxygen is, or hydrogen, either. I don't even know whether there are any such things at all. I see certain effects in my experiments which I must attribute to some cause, and I call that cause oxygen, because I must call it something; and other effects which I must attribute to another cause, and I call that hydrogen. But as for oxygen, I don't know whether it really exists. I think it very possible that it is only an effect of something else—another form of a something, which seems to make phosphorus, iodine, bromine, and certain other substances: and as for hydrogen—I know as little about it. I don't know but what all the metals, gold, silver, iron, tin, sodium, potassium, and so forth, are not different forms of hydrogen, or of something else which is the parent of hydrogen. In fact, I know but very little about the matter; except this, that I do know very little; and that the more I experiment, and the more I analyse, the more unexpected puzzles and wonders I find, and the more I expect to find till my dying day. True, I know a vast number of facts and laws, thank God; and some very useful ones among them: but as to the ultimate and first causes of those facts and laws, I know no more than the shepherd-boy outside; and can say no more than he does, when he reads in the Psalms at school: "I, and all around me, are fearfully and wonderfully made; marvellous are Thy works, and that my soul knoweth right well."

And so, my friends, though I have seemed to talk to you of great matters this night; of the making and the destruction of world after world: yet what does all I have said come to? I have not got one step beyond what the old Psalmist learnt amid the earthquakes and

volcanoes of the pastures and the forests of Palestine, three thousand years ago. I have not added to his words; I have only given you new facts to prove that he had exhausted the moral lesson of the subject, when he said:

These all wait upon thee, that thou mayest give them their meat in due season.

Thou givest, and they gather: thou openest thy hand, and they are filled with good.

Thou hidest thy face, they are troubled; thou takest away their breath; they die and return to their dust.

Thou sendest forth thy spirit, they are created; and thou renewest the face of the earth.

But—The glory of the Lord shall endure for ever. The Lord shall rejoice in his works. Amen.

HOW TO STUDY NATURAL HISTORY.

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LADIES AND GENTLEMEN, I speak to you to-night as to persons assembled, somewhat, no doubt, for amusement, but still more for instruction. Institutions such as this were originally founded for the purpose of instruction; to supply to those who wish to educate themselves some of the advantages of a regular course of scholastic or scientific training, by means of classes and of lectures.

I myself prize classes far higher than I do lectures. From my own experience, a lecture is often a very dangerous method of teaching; it is apt to engender in the mind of men ungrounded conceit and sciolism, or the bad habit of knowing about subjects without really knowing the subject itself. A young man hears an interesting lecture, and carries away from it doubtless a great many new facts and results: but he really must not go home fancying himself a much wiser man; and why? Because he has only heard the lecturer's side of the story. He has been forced to take the facts and the results on trust. He has not examined the facts for

* Lecture delivered at Reading, 1846.

himself. He has had no share in the process by which the results were arrived at. In short, he has not gone into the real scientia, that is, the "knowing" of the matter. He has gained a certain quantity of second-hand information: but he has gained nothing in mental training, nothing in the great "art of learning," the art of finding out things for himself, and of discerning truth from falsehood. Of course, where the lecture is a scientific one, illustrated by diagrams, this defect is not so extreme: but still the lecturer who shows you experiments, is forced to choose those which shall be startling and amusing, rather than important; he is seldom or never able, unless he is a man of at once the deepest science and the most extraordinary powers of amusing, to give you those experiments in the proper order which will unfold the subject to you step by step; and after all, an experiment is worth very little to you, unless you perform it yourself, ask questions about it, or vary it a little to solve difficulties which arise in your own mind.

Now mind—I do not say all this to make you give up attending lectures. Heaven forbid. They amuse, that is, they turn the mind off from business; they relax it, and as it were bathe and refresh it with new thoughts, after the day's drudgery or the day's commonplaces; they fill it with pleasant and healthful images for afterthought. Above all, they make one feel what a fair, wide, wonderful world one lives in; how much there is to be known, and how little one knows; and to the earnest man suggest future subjects of study. I only ask you not to expect from lectures what they can never give; but as to what they can give, I consider, I assure you, the lecturer's vocation a most honourable

one in the present day, even if we look on him as on a mere advertiser of nature's wonders. As such I appear here to-night; not to teach you natural history; for that you can only teach yourselves: but to set before you the subject and its value, and if possible, allure some of you to the study of it.

I have said that lectures do not supply mental training; that only personal study can do that. The next question is, What study? And that is a question which I do not answer in a hurry, when I say, The study of natural history. It is not, certainly, a study which a young man entering on the business of self-education would be likely to take up. To him, naturally, man is the most important subject. His first wish is to know the human world; to know what men are, what they have thought, what they have done. And therefore, you find that poetry, history, politics, and philosophy are the matters which most attract the self-guided student. I do not blame him, but he seems to me to be beginning at the middle, rather than at the beginning. I fell into the same fault myself more than once, when I was younger, and meddled in matters too high for me, instead of refraining my soul, and keeping it low; so I can sympathise with others who do so. But I can assure them that they will find such lofty studies do them good only in proportion as they have first learnt the art of learning. Unless they have learnt to face facts manfully, to discriminate between them skilfully, to draw conclusions from them rigidly; unless they have learnt in all things to look, not for what they would like to be true, but for what is true, because God has done it, and it cannot be undone—then they will be in danger of taking up only the

books which suit their own prejudices—and every one has his prejudices—and using them, not to correct their own notions, but to corroborate and pamper them; to confirm themselves in their first narrow guesses, instead of enlarging those guesses into certainty. The son of a Tory turn will read Tory books, the son of a Radical turn Radical books; and the green spectacles of party and prejudice will be deepened in hue as he reads on, instead of being thrown away for the clear white glass of truth, which will show him reason in all honest sides, and good in all honest men.

But, says the young man, I wish to be wide-minded and wide-hearted—I study for that very purpose. I will be fair, I will be patient, I will hear all sides ere I judge. And I doubt not that he speaks honestly. But (I quote with all reverence) though the spirit be willing, the flesh is weak. Studies which have to do with man's history, man's thoughts, man's feelings, are too exciting, too personal, often, alas, too tragical, to allow us to read them calmly at first. The men and women of whom we read are so like ourselves (for the human heart is the same in every age), that we unconsciously begin to love or hate them in the first five minutes, and read history as we do a novel, hurrying on to see when the supposed hero and heroine get safely married, and the supposed villain safely hanged, at the end of the chapter, having forgotten all the while, in our haste, to ascertain which is the hero and which is the villain. Mary Queen of Scots was "beautiful and unfortunate"—what heart would not bleed for a beautiful woman in trouble? Why stop to ask whether she brought it on herself? She was seventeen years in prison. Why stop to ascertain what sort of a

prison it was? And as for her guilt, the famous Casket Letters were, of course, a vile forgery. Impossible that they could be true. Hoot down the cold-hearted, and disagreeable, and troublesome man of facts, who will persist in his stupid attempt to disenchant you, and repeat—But the Casket Letters were not a forgery, and we can prove it, if you will but listen to the facts. Her prison, as we will show you (if you will be patient and listen to facts), consisted in greater pomp and luxury than that of most noblemen, with horses, hounds, books, music, liberty to hunt and amuse herself in every way, even in intriguing with every court of Europe, as we can show you again, if you will be patient and listen to facts. And she herself was a very wicked and false woman, an adulteress and a murderess (though fearfully ill-trained in early youth), who sowed the wind, poor wretch, from girlhood to old age, and therefore reaped the whirlwind, receiving the just reward of her deeds. Catherine of Russia, meanwhile, instead of being beautiful and unfortunate, was only handsome and successful. Brand her as a disgrace to human nature. The morals and ways of the two were pretty much on a par, with these exceptions in Catherine's favour—that she had strong passions, Mary none; that she lived in outer darkness and practical heathendom, while Mary had the light shining all round her, and refused it deliberately again and again. What matter to the sentimentalist? Hiss the stupid hard-hearted man of facts, by all means. What if he be right? He has no business to be right; we will consider him wrong accordingly, of our own sovereign will and pleasure. For after all, if we had the facts put before us (says the conscience of many a hearer), we could not judge of

them; we read to be amused and instructed, not to study cases like so many barristers. So is history read. And so, alas, is history written, too often, for want of a steady and severe training which would enable people to judge dispassionately of facts. In politics the case is the same. In poetry, which appeals more directly to the feelings, it must needs be still worse; as has been shown sadly enough of late by the success of several poems, in which every possible form of bad taste has only met with unbounded admiration from the many who have not had their senses exercised to discern between good and evil.

Now what seems to me to be wanted for young minds, is a study in which no personal likes or dislikes shall tempt them out of the path of mental honesty; a study in which they shall be free to look at facts exactly as they are, and draw their conclusions patiently and dispassionately. And such a study I have found in that of natural history.

Do not fancy it, I beg you, an easy thing to judge fairly of facts; even to discover the facts at all, when they are staring you in the face; and to see what it is that you do see. Any lawyer will tell you, that if you ask three honest men to bear testimony concerning an event which happened but yesterday, none of them, if he be at all an interested party, will give you exactly the same account of it: not that he wishes to say what is untrue; but that different parts of the whole matter having struck each man with different force, a different picture has been left on each man's memory. I have been utterly astounded of late, in investigating these strange stories of table-turning and spirit-rapping, to find how even clear-headed and well-instructed persons

(as one had fancied them) become unable to examine fairly into a thing, the moment the desire to believe has entered the heart; and how no amount of mere cultivation, if the scientific habit of mind be wanting, can prevent people from finding (as in table-turning) miracles in the most simple mechanical accidents; or from becoming (as in spirit-rapping) the dupes of the most clumsy, palpable, and degrading impostures, even after they have been exposed over and over again in print. Humiliating, indeed, it is, in this so self-confident and boastful nineteenth century, amid steam-engines, railroads, electric telegraphs, and all the wonders of our inductive science, to find exploded superstitions leaping back into life even more monstrous and irrational than in past ages, and to see our modern Pharisees and Sadducees, like those in Judea of old, seeking after a sign of an unseen world; and being unable to find one either in the heaven above or in the earth beneath, discovering it at last (I am almost ashamed to speak the words) under the parlour-table.

Against such extravagances, and against the loose sentimental tone of mind which begets them, hardly anything would be a better safeguard than the habitual study of nature. The chemist, the geologist, the botanist, the zoologist, has to deal with facts which will make him master of them, and of himself, only in proportion as he obeys them. Many of you doubtless know Lord Bacon's famous apothegm, Nature is only conquered by obeying her; and will understand me when I say, that you cannot understand, much less use for scientific purposes, the meanest pebble, unless you first obey that pebble. Paradoxical; but true.

See this pebble which I hold in my hand, picked up out of the street as I came along; it shall be my only object to-night. There the thing is; and is as it is, and in no other way; and such it will be, and so it will behave and act, in spite of me, and all my fancies about it, and notions of what it ought to have been like, and what it ought to have done. It is a thought of God's; and strong by the eternal laws of matter, which are the will of God. It has the whole universe, sun, and stars, and all, backing it by God's appointment, to keep it where it is and what it is; and till (as Lord Bacon has it) I have discovered and obeyed the will of God revealed in that pebble, it is to me a riddle more insoluble than the Sphinx's, a fortress more impregnable than Sevastopol. I may crush it: but destroying is not conquering: but I cannot even mend the road with it prudently, until I have discovered whether Almighty God has made it fit to mend roads with. I may have the genius of a Plato or of a Shakespeare, but all my genius will not avail to penetrate that pebble, or see anything in it but a little round dirty stone, until I have treated the pebble with reverence, as a thing independent of my likes and dislikes, fancies, and aspirations; and have asked it humbly to tell me its story, taking counsel meanwhile of hundreds of kindred pebbles, each as silent and reserved as this one; and watched and listened patiently, through many mistakes and misreadings, to what it has to say for itself, and what God has made it to be. And then at last that little black rounded pebble, from the street outside, may, and will surely, if I be patient and honest enough, tell me a tale wilder and grander than any which I could have dreamed for myself; will

shame the meanness of my imagination, by the awful magnificence of God's facts, and say to me:

"Ages and Æons since, thousands on thousands of years before there was a man to till the ground, I the little pebble was a living sponge, in the milky depths of the great chalk ocean; and hundreds of living atomies, each more fantastic than a ghost-painter's dreams, swam round me, and grew on me, and multiplied, till I became a tiny hive of wonders, each one of which would take you a life to understand. And then, I cannot yet tell you how, and till I tell you you will never know, the delicate flint-needles in my skin gathered other particles of flint to them, and I and all my inhabitants became a stone; and the chalk-mud settled round us, I know not how, and covered us in; and for ages on ages I lay buried in the nether dark, and felt the glow of the nether fires, and was cracked and tossed by a hundred earthquakes. Again and again I have been part of an island, and then again sunk beneath the sea, to be upheaved again after long centuries, till I saw the light once more, and dropped from the face of some chalk cliff far away among high hills which have long since been swept off the face of the earth, and was tossed by currents till I became a pebble on the beach, while Reading was a sand-bank in a shallow sea. There I lay and rolled till I was rounded, for many a century more; till flood after flood past over me, and a new earth was made; and I was mixed up with fresh flints from wasting chalk-hills, and with freestones from the Gloucestershire wolds, and with quartz-boulders from the mountains of Wales, while over me swept the carcases of drowned elephants and bisons, and many a monstrous beast;

and above me floated uprooted palms, and tropic fruits and seeds, and the wrecks of a dying world. And then there came another age—

> And it grew wondrous cold;
> And ice mast-high came floating by,
> As green as emerald;

and as the icebergs melted in the sun, the stones and the silt fell out of them, and covered me up; and I was in darkness once more, vexed by many an earthquake, till I became part of this brave English land. And now I am a pebble here in Reading street, to be ground beneath the wheels of busy men: and yet you cannot kill me, or hinder my fulfilling the law which cannot be broken. This year I am a pebble in the street; and next year I shall be dust upon the fields above; and the year after that I shall be alive again, and rise from the ground as fair green wheat-stems, bearing up food for the use of man. And even after that you cannot kill me. The trampled and sodden straw will rot only to enter into a new life; and I shall pass through a fresh cycle of strange adventures, age after age, till time shall be no more; doing my work in my generation, and fulfilling to the last the will of God, as faithfully as when I was the water-breathing sponge in the abysses of the old chalk sea."

All this and more, gentlemen and ladies, the pebble could tell to you, and will: but he is old and venerable, and like old men, he wishes to be approached with respect, and does not like to be questioned too much or too rapidly; so that you must not be offended if you meet with more than one rebuff from him; or if he keeps stubborn silence, till he has seen that you are a

modest and attentive person, to whom it is worth while to open a little of his forty or fifty thousand years' experience.

Second only to the good effect of this study on the logical faculty, seems to me to be its effect on the imagination. Not merely in such objects as the pebble, whose history I have so hastily, but I must add faithfully, sketched; but in the tiniest piece of mould on a decayed fruit, the tiniest animalcule from the stagnant pool, will imagination find inexhaustible wonders, and fancy a fairy-land. And I beg my elder hearers not to look on this as light praise. Imagination is a valuable thing; and even if it were not, it is a thing, a real thing, a faculty which every one has, and with which you must do something. You cannot ignore it; it will assert its own existence. You will be wise not to neglect it in young children; for if you do not provide wholesome food for it, it will find unwholesome food for itself. I know that many, especially men of business, are inclined to sneer at it, and ask what is the use of it? The simple answer is, God has made it; and He has made nothing in vain. But you will find that in practice, in action, in business, imagination is a most useful faculty, and is so much mental capital, whensoever it is properly trained. Consider but this one thing, that without imagination no man can possibly invent even the pettiest object; that it is one of the faculties which essentially raises man above the brutes, by enabling him to create for himself; that the first savage who ever made a hatchet must have imagined that hatchet to himself ere he began it; that every new article of commerce, every new opening for trade, must be arrived at by acts of imagination; by

the very same faculty which the poet or the painter employs, only on a different class of objects; remember that this faculty is present in some strength in every mind of any power, in every mind which can do more than follow helplessly in the beaten track, and do nothing but what it has seen others do already: and then see whether it be not worth while to give the young a study which above all others is fitted to keep this important and universal faculty in health. Now, from fifty to five-and-twenty years ago, under the influence of the Franklin and Edgeworth school of education, imagination was at a discount. That school was a good school enough: but here was one of its faults. It taught people to look on imagination as quite a useless, dangerous, unpractical, bad thing, a sort of mental disease. And now, as is usual after an unfair depreciation of anything, has come a revolution; and an equally unfair glorifying of the imagination; the present generation have found out suddenly that the despised faculty is worth something, and therefore are ready to believe it worth everything; so that nowadays, to judge from the praise heaped on some poets, the mere possession of imagination, however ill regulated, will atone for every error of false taste, bad English, carelessness for truth; and even for coarseness, blasphemy, and want of common morality; and it is no longer charity, but fancy, which is to cover the multitude of sins.

The fact is, that youth will always be the period of imagination; and the business of a good education will always be to prevent that imagination from being thrown inward, and producing a mental fever, diseasing itself and the whole character by feeding on its own

fancies, its own day dreams, its own morbid feelings, its likes and dislikes; even if it do not take at last to viler food, to French novels, and lawless thoughts, which are but too common, alas! though we will not speak of them here.

To turn the imagination not inwards, but outwards; to give it a class of objects which may excite wonder, reverence, the love of novelty and of discovering, without heating the brain or exciting the passions—this is one of the great problems of education; and I believe from experience that the study of natural history supplies in great part what we want. The earnest naturalist is pretty sure to have obtained that great need of all men, to get rid of self. He who, after the hours of business, finds himself with a mind relaxed and wearied, will not be tempted to sit at home dreaming over impossible scenes of pleasure, or to go for amusement to haunts of coarse excitement, if he have in every hedge-bank, and woodland, and running stream, in every bird among the boughs, and every cloud above his head, stores of interest which will enable him to forget awhile himself, and man, and all the cares, even all the hopes of life, and to be alone with the inexhaustible beauty and glory of Nature, and of God who made her. An hour or two every day spent after business-hours in botany, geology, entomology, at the telescope or the microscope, is so much refreshment gained for the mind for to-morrow's labour, so much rest for irritated or anxious feelings, often so much saved from frivolity or sin. And how easy this pursuit. How abundant the subjects of it! Look round you here. Within the reach of every one of you are wonders beyond all poets' dreams. Not a hedge-bank but has

its hundred species of plants, each different and each beautiful; and when you tire of them—if you ever can tire—a trip into the meadows by the Thames, with the rich vegetation of their dikes, floating flower-beds of every hue, will bring you as it were into a new world, new forms, new colours, new delight. You ask why this is? And you find yourself at once involved in questions of soil and climate, which lead you onward, step by step, into the deepest problems of geology and chemistry. In entomology, too, if you have any taste for the beauties of form and colour, any fondness for mechanical and dynamical science, the insects, even to the smallest, will supply endless food for such likings; while their instincts and their transformations, as well as the equally wondrous chemical transformation of salts and gases into living plants, which agricultural chemistry teaches you, will tempt you to echo every day Mephistopheles's magic song, when he draws wine out of the table in Auersbach's cellar:

> Wine is grapes, and grapes are wood—
> The wooden board yields wine as good:
> It is but a deeper glance
> Into Nature's countenance.
> All is plain to him who seeth;
> Lift the veil and look beneath,
> And behold, the wise man saith,
> Miracles, if you have faith.

Believe me you need not go so far to find more than you will ever understand. An hour's summer walk, in the company of some one who knows what to look for and how to look for it, by the side of one of those stagnant dikes in the meadows below, would furnish you with subjects for a month's investigation, in the

form of plants, shells, and animalcules, on each of which a whole volume might be written. And even at this seemingly dead season of the year, fancy not that nature is dead—not even that she sleeps awhile. Every leaf which drops from the bough, to return again into its gases and its dust, is working out chemical problems which have puzzled a Boyle and a Lavoisier, and about which a Liebig and a Faraday will now tell you that they have but some dim guess, and that they stand upon the threshold of knowledge like (as Newton said of himself) children gathering a few pebbles, upon the shore of an illimitable sea. In every woodland, too, innumerable fungi are at work, raising from the lower soil rich substances, which, strewed on the surface by quick decay, will form food for plants higher than themselves; while they, by their variety and beauty, both of form and colour, might well form studies for any painter, and by the obscure laws of their reproduction, studies for any philosopher. Why, there is not a heap of dead leaves among which by picking it through carefully you might not find some twenty species of delicate and elegant land-shells; hardly a tree-foot at which, among the moss and mould, you might not find the chrysalides of beautiful moths, where caterpillars have crawled down the trunk in autumn, to lie there self-buried and die to live again next spring in a new and fairer shape. And if you cannot reach even there, go to the water-but in the nearest yard, and there, in one pinch of green scum, in one spoonful of water, behold a whole "Divina Commedia" of living forms, more fantastic a thousand times than those with which Dante peopled his unseen world: and then feel, as you should feel, abashed at the

ignorance and weakness of mortal man; abashed still more at that rash conceit of his, which makes him fancy himself the measure of all things; and say with me: "Oh Lord, thy works are manifold; thy ways are very deep. In wisdom hast thou made them all, the earth is full of thy riches. Thou openest thy hand, and fillest all things living with plenteousness; they continue this day according to thine ordinance, for all things serve thee. Thou hast made them fast for ever and ever; thou hast given them a law which shall not be broken. Let them praise the name of the Lord; for he spake the word and they were made, he commanded, and they were created."

This I shall say, but little more than this, on the religious effect of the study of natural history. I do not wish to preach a sermon to you. I can trust God's world to bear better witness than I can, of the Loving Father who made it. I thank him from my own experience for the testimony of His Creation, only next to the testimony of His Bible. I have watched scientific discoveries which were supposed in my boyhood to be contrary to revelation, found out one by one to confirm and explain revelation, as crude and hasty theories were corrected by more abundant facts, and men saw more clearly what both the Bible and Nature really did say; and I can trust that the same process will go on for ever, and that God's earth and God's word will never contradict each other. I have found the average of scientific men, not less, but more, godly and righteous men than the average of their neighbours; and I can trust that this will be more and more the case as science deepens and widens. And therefore I can trust that every patient, truthful, and

healthful mind will, the more it contemplates the works of God, re-echo St. Paul's great declaration that the Invisible things of God are clearly seen from the foundation of the world, being understood by the things which are made, even His eternal power and Godhead. And so trusting, I pass on to a lower view of the subject, and yet not an unnecessary one.

In an industrial country like this, the practical utility of any study must needs be always thrown into the scale; and natural history seems at first sight somewhat unpractical. What money will it earn for a man in after life?—is a question which will be asked; and which it is folly to despise. For if the only answer be: "None at all," a man has a right to rejoin: "Then let me take up some pursuit which will train and refresh my mind as much as this one, and yet be of pecuniary benefit to me some day." If you can find such a study, by all means follow it: but I say that this study too may be of great practical benefit in after life. How much money have I, young as I am, seen wasted for want of a little knowledge of botany, geology, or chemistry. How many a clever man becomes the dupe of empirics for want of a little science. How many a mine is sought for where no mine could be; or crop attempted to be grown, where no such crop could grow. How many a hidden treasure, on the other hand, do men walk over unheeding. How many a new material, how many an improved process in manufacture is possible, yet is passed over, for want of a little science. And for the man who emigrates, and comes in contact with rude nature teeming with unsuspected wealth, of what incalculable advantage to have if it be but the rudiments of those

sciences, which will tell him the properties, and therefore the value, of the plants, the animals, the minerals, the climates with which he meets? True—home-learnt natural history will not altogether teach him about these things, because most of them must needs be new: but it will teach him to compare and classify them as he finds them, and so by analogy with things already known to him, to discover their intrinsic worth.

For natural history stands to man's power over Nature, that is, to his power of being useful to himself and to mankind, in the same relation as do geography, grammar, arithmetic, geometry, political economy; none of them, perhaps, bearing directly on his future business in life; but all training his mind for his business, all giving him the rudiments of laws which he will hereafter work out and apply to his profession. And even at home, be sure that such studies will bear fruit in after life. The productive wealth of England is not exhausted, doubt it not; our grandchildren may find treasures in this our noble island of which we never dreamed, even as we have found things of which our forefathers dreamed not. Recollect always that a great market town like this is not merely a commercial centre; not perhaps even a commercial centre at all: but that she is an agricultural centre, and one of the most important in England; that the increase of science here will be sure more or less to extend itself to the neighbourhood: and then lay to heart this one fact. A friend of mine, and one whom I am proud to call my friend, succeeding to an estate, thought good to cultivate it himself. And being a man of common sense, he thought good to know something of what

he was doing. And he said to himself: The soil, and the rain, and the air are my raw materials. I ought surely then to find out what soil, and rain, and air are; so I must become a geologist and a meteorologist. Vegetable substances are what I am to make. And I ought surely to know what it is that I am making; so I must become a botanist. The raw material does somehow or other become manufactured into the produce; the soil into the vegetable. I ought surely to know a little about the processes of my own manufacture; so I must learn chemistry. Chance and blind custom are not enough for me. At best they can but leave me where they found me, at their mercy. Science I need; and science I will acquire. What was the result? After many a mistake and disappointment, he succeeded in discovering on his own estate a mine of unsuspected wealth—not of gold indeed, but of gold's worth—the elements of human food. He discovered why some parts of his estate were fertile, while others were barren; and by applying the knowledge thus gained, he converted some of his most barren fields into his most fertile ones; he preserved again and again his crops from blight, while those of others perished all around him; he won for himself wealth, and the respect and honour of men of science; while those around him, slowly opening their eyes to his improvements, followed his lessons at second-hand, till the whole agriculture of an important district has become gradually but permanently improved, under the auspices of one patient and brave man, who knew that knowledge was power, and that only by obeying nature can man conquer her.

Bear in mind both these last great proverbs; and

combine them in your mind. Remember that while England is, and ever will be, behindhand in metaphysical and scholastic science, she is the nation which above all others has conquered nature by obeying her; that as it pleased God that the author of that proverb, the father of inductive science, Bacon Lord Verulam, should have been an Englishman, so it has pleased Him that we, Lord Bacon's countrymen, should improve that precious heirloom of science, inventing, producing, exporting, importing, till it seems as if the whole human race, and every land from the equator to the pole must henceforth bear the indelible impress and sign manual of English science.

And bear in mind, as I said just now, that this study of natural history is the grammar of that very physical science which has enabled England thus to replenish the earth and subdue it. Do you not see, then, that by following these studies you are walking in the very path to which England owes her wealth; that you are training in yourselves that habit of mind which God has approved as the one which He has ordained for Englishmen, and are doing what in you lies toward carrying out, in after life, the glorious work which God seems to have laid on the English race, to replenish the earth and subdue it?

One word more, and I have done. Unless you are already tired of hearing me, I would suggest a few practical hints before we part. The best way of learning these matters is by classes, in which men may combine and interchange their thoughts and observations. The greatest savants find this; and have their Microscopic Society, Linnæan, Royal, Geological Societies, British Associations, and what not, in which all may know what each

has done, and each share in the learning of all; for as iron sharpeneth iron, so a man sharpens the face of his friend. I have nothing to say against debating societies: perhaps it was my own fault that whenever I belonged to one as a young man, I found them inclined to make me conceited, dictatorial, hasty in my judgments, trying to state a case before I had investigated it, to teach others before I had taught myself, to make a fine speech, not to find out the truth; till in, I think, a wise moment for me, I vowed at twenty never to set foot in one again, and kept my vow. Be that as it may, I wish that side by side with the debating society, I could see young men joining in natural history societies; going out in company on pleasant evenings to search together after the hidden treasures of God's world, and read the great green book which lies open alike to peasant and to peer; and then meeting, say once a week, to debate, not of opinions but of facts; to show each what they had found, to classify and explain, to learn and to wonder together. In such a class many appliances would be possible. A microscope, for instance, or chemical apparatus, might belong to the society, which each individual by himself would not be able to afford; while as for books—books on these subjects are now published at a marvellous cheapness, which puts them within the reach of every one, and of an excellence which twenty years ago was impossible. Any working man in this town might now, especially in a class, consult scientific books, for which I, as a lad, twenty years ago, was sighing in vain; nay, many of which, twenty years ago, the richest nobleman could not have purchased; for the simple reason, that, dear or cheap, they did not exist.

Such classes, too, would be the easiest, cheapest, and pleasantest way of establishing what ought to exist, I think, in connection with every institution like this, namely, a museum. If the young men were really ready and willing to collect objects of interest, I doubt not that public-spirited men would be found, who would undertake the expense of mounting them in a museum. And you cannot imagine, I assure you, how large and how interesting a museum might be formed of the natural curiosities of a neighbourhood like this, I may say, indeed, of any neighbourhood or of any parish: but your museum need not be confined to the neighbourhood. Societies now exist in every part of England, who will be happy to exchange their duplicates for yours. As your collection increased in importance, old members abroad would gladly contribute foreign curiosities to your stock. Neighbouring gentlemen would send you valuable objects which had been lumbering their houses, uncared for, because they stood alone, and formed no part of a collection; and I, for one, would be happy to add something from the fauna and flora of those moorlands, where I have so long enjoyed the wonders of nature; never, I can honestly say, alone; because when man was not with me, I had companions in every bee, and flower, and pebble; and never idle, because I could not pass a swamp, or a tuft of heather, without finding in it a fairy tale of which I could but decipher here and there a line or two, and yet found them more interesting than all the books, save one, which were ever written upon earth.

THE NATURAL THEOLOGY OF THE FUTURE.

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Read at Sion College, January 10th, 1871.

WHEN I accepted the unexpected and undeserved honour of being allowed to lecture here, the first subject which suggested itself to me was Natural Theology.

It is one which has taken up much of my thought for some years past,* which seems to me more and more

* Novalis, I think, says that one's own thought gains quite infinitely in value as soon as one finds it shared by even one other human being. The saying has proved true, at least, to me. The morning after this paper was read, I received a book, "The Genesis of Species, by St. George Mivart, F.R.S." The name of the author demanded all attention and respect; and as I read on, I found him, to my exceeding pleasure, advocating views which I had long held, with a learning and ability to which I have no pretensions. The book will, doubtless, excite much useful criticism and discussion in the scientific world. I hope that it may do the same in the clerical world; and I earnestly beg those clergymen who heard me with so much patience and courtesy at Sion College, to ponder well Mr. Mivart's last chapter, on "Theology and Evolution."

important, and which is just now somewhat forgotten; I therefore determined to say a few words on it to-night. I do not pretend to teach but only to suggest; to point out certain problems of Natural Theology, the further solution of which ought, I think, to be soon attempted.

I wish to speak, remember, not on natural religion, but on natural theology. By the first, I understand what can be learned from the physical universe of man's duty to God and to his neighbour; by the latter, I understand what can be learned concerning God Himself. Of natural religion I shall say nothing. I do not even affirm that a natural religion is possible: but I do very earnestly believe that a natural theology is possible; and I earnestly believe also that it is most important that natural theology should, in every age, keep pace with doctrinal or ecclesiastical theology.

Bishop Butler certainly held this belief. His "Analogy of Religion, Natural and Revealed, to the Constitution and Course of Nature"—a book for which I entertain the most profound respect—is based on a belief that the God of Nature and the God of Grace are one; and that, therefore, the God who satisfies our conscience ought more or less to satisfy our reason also. To teach that was Butler's mission, and he fulfilled it well. But it is a mission which has to be re-filled again and again, as human thought changes and human science develops; for if in any age or country the God who seems to be revealed by Nature seems different from the God who is revealed by the then popular religion, then that God, and the religion

which tells of that God, will gradually cease to be believed in.

For the demands of Reason (as none knew better than good Bishop Butler) must be and ought to be satisfied. And when a popular war arises between the reason of a generation and its theology, it behoves the ministers of religion to inquire, with all humility and godly fear, on which side lies the fault: whether the theology which they expound is all that it should be, or whether the reason of those who impugn it is all that it should be.

For me, as (I trust) an orthodox priest of the Church of England, I believe the theology of the National Church of England, as by law established, to be eminently rational as well as scriptural. It is not, therefore, surprising to me that the clergy of the Church of England, since the foundation of the Royal Society in the seventeenth century, have done more for sound physical science than the clergy of any other denomination; or that the three greatest natural theologians with which I, at least, am acquainted—Berkeley, Butler, and Paley—should have belonged to our Church. I am not unaware of what the Germans of the eighteenth century have done. I consider Goethe's claims to have advanced natural theology very much over-rated: but I do recommend to young clergymen Herder's "Outlines of the Philosophy of the History of Man" as a book (in spite of certain defects) full of sound and precious wisdom. But it seems to me that English natural theology in the eighteenth century stood more secure than that of any other nation, on the foundation which Berkeley,

Butler, and Paley had laid; and that if our orthodox thinkers for the last hundred years had followed steadily in their steps, we should not be deploring now a wide, and as some think increasing, divorce between Science and Christianity.

But it was not so to be. The impulse given by Wesley and Whitfield turned (and not before it was needed) the earnest mind of England almost exclusively to questions of personal religion; and that impulse, under many unexpected forms, has continued ever since. I only state the fact—I do not deplore it; God forbid! Wisdom is justified of all her children, and as, according to the wise American, "it takes all sorts to make a world," so it takes all sorts to make a living Church. But that the religious temper of England for the last two or three generations has been unfavourable to a sound and scientific development of natural theology, there can be no doubt.

We have only, if we need proof, to look at the hymns—many of them very pure, pious, and beautiful—which are used at this day in churches and chapels by persons of every shade of opinion. How often is the tone in which they speak of the natural world one of dissatisfaction, distrust, almost contempt. "Disease, decay, and death around I see," is their key-note, rather than "O all ye works of the Lord, bless Him, praise Him, and magnify Him together." There lingers about them a savour of the old monastic theory, that this earth is the devil's planet, fallen, accursed, goblin-haunted, needing to be exorcised at every turn before it is useful or even safe for man. An age which has adopted as its most popular hymn a paraphrase of the mediæval monk's "Hic breve vivitur," and in

which stalwart public-school boys are bidden in their chapel worship to tell the Almighty God of Truth that they lie awake weeping at night for joy at the thought that they will die and see Jerusalem the Golden—is doubtless a pious and devout age; but not —at least as yet—an age in which natural theology is likely to attain a high, a healthy, or a scriptural development.

Not a scriptural development. Let me press on you, my clerical brethren, most earnestly this one point. It is time that we should make up our minds what tone Scripture does take toward Nature, natural science, natural theology. Most of you, I doubt not, have made up your minds already, and in consequence have no fear of natural science, no fear for natural theology. But I cannot deny that I find still lingering here and there certain of the old views of nature of which I used to hear but too much here in London some five-and-thirty years ago; not from my own father, thank God! for he, to his honour, was one of those few London clergy who then faced and defended advanced physical science; but from others—better men too than I shall ever hope to be—who used to consider natural theology as useless, fallacious, impossible, on the ground that this Earth did not reveal the will and character of God, because it was cursed and fallen; and that its facts, in consequence, were not to be respected or relied on. This, I was told, was the doctrine of Scripture, and was therefore true. But when, longing to reconcile my conscience and my reason on a question so awful to a young student of natural science, I went to my Bible, what did I find? No word of all this. Much—thank God, I may say

one continuous undercurrent—of the very opposite of all this. I pray you bear with me, even though I may seem impertinent. But what do we find in the Bible, with the exception of that first curse? That, remember, cannot mean any alteration in the laws of nature by which man's labour should only produce for him henceforth thorns and thistles. For, in the first place, any such curse is formally abrogated in the eighth chapter and twenty-first verse of the very same document—"I will not again curse the earth any more for man's sake. While the earth remaineth, seed-time and harvest, cold and heat, summer and winter, day and night shall not cease." And next, the fact is not so; for if you root up the thorns and thistles, and keep your land clean, then assuredly you will grow fruit-trees and not thorns, wheat and not thistles, according to those laws of Nature which are the voice of God expressed in facts.

And yet the words are true. There is a curse upon the earth, though not one which, by altering the laws of nature, has made natural facts untrustworthy. There is a curse on the earth; such a curse as is expressed, I believe, in the old Hebrew text, where the word "adamah" (correctly translated in our version "the ground") signifies, as I am told, not this planet, but simply the soil from whence we get our food; such a curse as certainly is expressed by the Septuagint and the Vulgate versions: "Cursed is the earth"—ἐν τοῖς ἔργοις σου; "in opere tuo," as the Vulgate has it—"in thy works." Man's work is too often the curse of the very planet which he misuses. None should know that better than the botanist, who sees whole regions desolate, and given up to sterility and literal

thorns and thistles, on account of man's sin and folly, ignorance and greedy waste. Well said that veteran botanist, the venerable Elias Fries, of Lund:

"A broad band of waste land follows gradually in the steps of cultivation. If it expands, its centre and its cradle dies, and on the outer borders only do we find green shoots. But it is not impossible, only difficult, for man, without renouncing the advantage of culture itself, one day to make reparation for the injury which he has inflicted: he is appointed lord of creation. True it is that thorns and thistles, ill-favoured and poisonous plants, well named by botanists rubbish plants, mark the track which man has proudly traversed through the earth. Before him lay original Nature in her wild but sublime beauty. Behind him he leaves the desert, a deformed and ruined land; for childish desire of destruction, or thoughtless squandering of vegetable treasures, has destroyed the character of nature; and, terrified, man himself flies from the arena of his actions, leaving the impoverished earth to barbarous races or to animals, so long as yet another spot in virgin beauty smiles before him. Here again, in selfish pursuit of profit, and consciously or unconsciously following the abominable principle of the great moral vileness which one man has expressed—'Après nous le Déluge'—he begins anew the work of destruction. Thus did cultivation, driven out, leave the East, and perhaps the deserts formerly robbed of their coverings; like the wild hordes of old over beautiful Greece, thus rolls this conquest with fearful rapidity from East to West through America; and the planter now often leaves the already exhausted land, and the eastern climate, become infertile through the

demolition of the forests, to introduce a similar revolution into the Far West." *

As we proceed, we find nothing in the general tone of Scripture which can hinder our natural theology being at once scriptural and scientific.

If it is to be scientific, it must begin by approaching Nature at once with a cheerful and reverent spirit, as a noble, healthy, and trustworthy thing: and what is that, save the spirit of those who wrote the 104th, 147th, and 148th Psalms—the spirit, too, of him who wrote that Song of the Three Children, which is, as it were, the flower and crown of the Old Testament, the summing up of all that is most true and eternal in the old Jewish faith; and which, as long as it is sung in our churches, is the charter and title-deed of all Christian students of those works of the Lord, which it calls on to bless Him, praise Him, and magnify Him for ever?

What next will be demanded of us by physical science? Belief, certainly, just now, in the permanence of natural laws. Why, that is taken for granted, I hold, throughout the Bible. I cannot see how our Lord's parables, drawn from the birds and the flowers, the seasons and the weather, have any logical weight, or can be considered as aught but capricious and fanciful illustrations—which God forbid—unless we look at them as instances of laws of the natural world, which find their analogues in the laws of the spiritual world, the kingdom of God. I cannot conceive a man's writing that 104th Psalm who had not the most deep, the most earnest sense of the per-

* Quoted from Schleiden's "The Plant, a Biography."—Lecture XI. *in fine.*

manence of natural law. But more: the fact is expressly asserted again and again. "They continue this day according to Thine ordinance, for all things serve Thee." "Thou hast made them fast for ever and ever. Thou hast given them a law which shall not be broken——"

Let us pass on, gentlemen. There is no more to be said about this matter.

But next, it will be demanded of us that natural theology shall set forth a God whose character is consistent with all the facts of nature, and not only with those which are pleasant and beautiful. That challenge was accepted, and I think victoriously, by Bishop Butler as far as the Christian religion is concerned. As far as the Scripture is concerned, we may answer thus:

It is said to us—I know that it is said: You tell us of a God of love, a God of flowers and sunshine, of singing birds and little children. But there are more facts in nature than these. There is premature death, pestilence, famine. And if you answer: Man has control over these; they are caused by man's ignorance and sin, and by his breaking of natural laws—what will you make of those destructive powers over which he has no control; of the hurricane and the earthquake; of poisons, vegetable and mineral; of those parasitic Entozoa whose awful abundance, and awful destructiveness in man and beast, science is just revealing—a new page of danger and loathsomeness? How does that suit your conception of a God of love?

We can answer: Whether or not it suits our conception of a God of love, it suits Scripture's conception of Him. For nothing is more clear—nay, is it not urged again and again, as a blot on Scripture?—that it reveals

a God not merely of love, but of sternness—a God in whose eyes physical pain is not the worst of evils, nor animal life (too often miscalled human life) the most precious of objects—a God who destroys, when it seems fit to Him, and that wholesale, and seemingly without either pity or discrimination, man, woman and child, visiting the sins of the fathers on the children, making the land empty and bare, and destroying from off it man and beast! This is the God of the Old Testament. And if any say (as is often too rashly said): This is not the God of the New: I answer, but have you read your New Testament? Have you read the latter chapters of St. Matthew? Have you read the opening of the Epistle to the Romans? Have you read the Book of Revelations? If so, will you say that the God of the New Testament is, compared with the God of the Old, less awful, less destructive, and therefore less like the Being—granting always that there is such a Being—who presides over nature and her destructive powers? It is an awful problem. But the writers of the Bible have faced it valiantly. Physical science is facing it valiantly now. Therefore natural theology may face it likewise. Remember Carlyle's great words about poor Francesca in the Inferno: "Infinite pity, yet also infinite rigour of law. It is so Nature is made. It is so Dante discerned that she was made."

There are two other points on which I must beg leave to say a few words. Physical science will demand of our natural theologians that they should be aware of their importance, and let (as Mr. Matthew Arnold would say) their thoughts play freely round them. I mean questions of Embryology and questions of Race.

On the first there may be much to be said, which is for the present best left unsaid, even here. I only ask you to recollect how often in Scripture those two plain old words, beget and bring forth, occur, and in what important passages. And I ask you to remember that marvellous essay on Natural Theology, if I may so call it in all reverence, the 139th Psalm, and judge for yourself whether he who wrote that did not consider the study of Embryology as important, as significant, as worthy of his deepest attention, as an Owen, a Huxley, or a Darwin. Nay, I will go farther still, and say, that in those great words—"Thine eyes did see my substance, yet being imperfect; and in Thy book all my members were written, which in continuance were fashioned, when as yet there was none of them," —in those words, I say, the Psalmist has anticipated that realistic view of embryological questions to which our most modern philosophers are, it seems to me, slowly, half unconsciously, but still inevitably, returning.

Next, as to Race. Some persons now have a nervous fear of that word, and of allowing any importance to difference of races. Some dislike it, because they think that it endangers the modern notions of democratic equality. Others because they fear that it may be proved that the negro is not a man and a brother. I think the fears of both parties groundless. As for the negro, I not only believe him to be of the same race as myself, but that—if Mr. Darwin's theories are true—science has proved that he must be such. I should have thought, as a humble student of such questions, that the one fact of the unique distribution of the hair in all races of human beings, was full moral proof that they had all

had one common ancestor. But this is not matter of natural theology. What is matter thereof, is this:

Physical science is proving more and more the immense importance of Race; the importance of hereditary powers, hereditary organs, hereditary habits, in all organised beings, from the lowest plant to the highest animal. She is proving more and more the omnipresent action of the differences between races; how the more favoured race (she cannot avoid using the epithet) exterminates the less favoured, or at least expels it, and forces it, under penalty of death, to adapt itself to new circumstances; and, in a word, that competition between every race and every individual of that race, and reward according to deserts, is (as far as we can see) an universal law of living things. And she says—for the facts of history prove it—that as it is among the races of plants and animals, so it has been unto this day among the races of men.

The natural theology of the future must take count of these tremendous and even painful facts: and she may take count of them. For Scripture has taken count of them already. It talks continually—it has been blamed for talking so much—of races, of families; of their wars, their struggles, their exterminations; of races favoured, of races rejected, of remnants being saved to continue the race; of hereditary tendencies, hereditary excellences, hereditary guilt. Its sense of the reality and importance of descent is so intense, that it speaks of a whole tribe or a whole family by the name of its common ancestor, and the whole nation of the Jews is Israel, to the end. And if I be told this is true of the Old Testament, but not of the New, I must answer: What! does not St. Paul hold the identity

of the whole Jewish race with Israel their forefather, as strongly as any prophet of the Old Testament? And what is the central historic fact, save One, of the New Testament, but the conquest of Jerusalem—the dispersion, all but destruction of a race, not by miracle, but by invasion, because found wanting when weighed in the stern balances of natural and social law?

Gentlemen, think of this. I only suggest the thought; but I do not suggest it in haste. Think over it—by the light which our Lord's parables, His analogies between the physical and social constitution of the world, afford—and consider whether those awful words, fulfilled then and fulfilled so often since—"The kingdom of God shall be taken from you, and given to a nation bringing forth the fruits hereof"—may not be the supreme instance, the most complex development of a law which runs through all created things, down to the moss which struggles for existence on the rock!

Do I say that this is all? That man is merely a part of Nature, the puppet of circumstances and hereditary tendencies? That brute competition is the one law of his life? That he is doomed for ever to be the slave of his own needs, enforced by an internecine struggle for existence? God forbid. I believe not only in Nature, but in Grace. I believe that this is man's fate only as long as he sows to the flesh, and of the flesh reaps corruption. I believe that if he will

> Strive upward, working out the beast,
> And let the ape and tiger die;

if he will be even as wise as the social animals; as the ant and the bee, who have risen, if not to the virtue of

all-embracing charity, at least to the virtues of self-sacrifice and patriotism,* then he will rise towards a higher sphere; toward that kingdom of God of which it is written: "He that dwelleth in love, dwelleth in God, and God in him."

Whether that be matter of natural theology, I cannot tell as yet. But as for all the former questions —all that St. Paul means when he talks of the law, and how the works of the flesh bring men under the law, stern and terrible and destructive, though holy and just and good,—they are matter of natural theology; and I believe that on them, as elsewhere,

* I am well aware what a serious question is opened up in these words. The fact that the great majority of workers among the social insects are barren females or nuns, devoting themselves to the care of other individuals' offspring, by an act of self-sacrifice, and that by means of that self-sacrifice these communities grow large and prosperous, ought to be well weighed just now; both by those who hold that morality has been evolved from perceptions of what was useful or pleasurable, and by those who hold as I do that morality is one, immutable and eternal. Those who take the former view (confounding, as Mr. Mivart well points out in his Genesis of Species, "material" and "formal" morality) have no difficulty in tracing the germs of the highest human morality in animals; for self-interest is, in their eyes, the ultimate ground of morality, and the average animal is utterly selfish. But certain animals perform acts, as in the case of working bees and ants, and (as I hold) in the case of mothers working for and protecting their offspring, which at least seem formally moral; because they seem founded on self-sacrifice. I am well aware, I say again, of the very serious admissions which we clergymen should have to make if we confessed that these acts really are that which they seem to be. But I do not see why we should not be as just to an ant as to a human being; I am ready, with Socrates, to follow the Logos whithersoever it leads; and I hope that Mr. Mivart will reconsider the two latter paragraphs of p. 196, and let his "thoughts play freely" round this curious subject. Perhaps, in so doing, he may lay his hand on an even sharper weapon than those which he has already used against the sensationalist theory of morals.

Scripture and science will be ultimately found to coincide.

But here we have to face an objection which you will often hear now from scientific men, and still oftener from non-scientific men; who will say: It matters not to us whether Scripture contradicts or does not contradict a scientific natural theology; for we hold such a science to be impossible and naught. The old Jews put a God into Nature, and therefore of course they could see, as you see, what they had already put there. But we see no God in Nature. We do not deny the existence of a God; we merely say that scientific research does not reveal Him to us. We see no marks of design in physical phenomena. What used to be considered as marks of design can be better explained by considering them as the results of evolution according to necessary laws; and you and Scripture make a mere assumption when you ascribe them to the operation of a mind like the human mind.

Now, on this point I believe we may answer fearlessly: If you cannot see it we cannot help you. If the heavens do not declare to you the glory of God, nor the firmament show you His handy-work, then our poor arguments about them will not show it. "The eye can only see that which it brings with it the power of seeing." We can only reassert that we see design everywhere, and that the vast majority of the human race in every age and clime has seen it. Analogy from experience, sound induction (as we hold) from the works not only of men but of animals, has made it an all but self-evident truth to us, that wherever there is arrangement, there must be an

arranger; wherever there is adaptation of means to an end, there must be an adapter; wherever an organisation, there must be an organiser. The existence of a designing God is no more demonstrable from Nature than the existence of other human beings independent of ourselves, or, indeed, the existence of our own bodies. But, like the belief in them, the belief in Him has become an article of our common sense. And that this designing mind is, in some respects, similar to the human mind, is proved to us (as Sir John Herschel well puts it) by the mere fact that we can discover and comprehend the processes of Nature.

But here again, if we be contradicted, we can only reassert. If the old words, "He that made the eye, shall He not see? He that planted the ear, shall He not hear?" do not at once commend themselves to the intellect of any person, we shall never convince that person by any arguments drawn from the absurdity of conceiving the invention of optics by a blind race, or of music by a deaf one.

So we will assert our own old-fashioned notion boldly; and more: we will say, in spite of ridicule, that if such a God exists, final causes must exist also. That the whole universe must be one chain of final causes. That if there be a Supreme Reason, He must have a reason, and that a good reason, for every physical phenomenon.

We will tell the modern scientific man—You are nervously afraid of the mention of final causes. You quote against them Bacon's saying, that they are barren virgins; that no physical fact was ever discovered or explained by them. You are right as far as

regards yourselves; you have no business with final causes, because final causes are moral causes, and you are physical students only. We, the natural theologians, have business with them. Your duty is to find out the How of things; ours, to find out the Why. If you rejoin that we shall never find out the Why, unless we first learn something of the How, we shall not deny that. It may be most useful, I had almost said necessary, that the clergy should have some scientific training. It may be most useful, I sometimes dream of a day when it will be considered necessary, that every candidate for ordination should be required to have passed creditably in at least one branch of physical science, if it be only to teach him the method of sound scientific thought. But our having learnt the How, will not make it needless, much less impossible, for us to study the Why. It will merely make more clear to us the things of which we have to study the Why; and enable us to keep the How and the Why more religiously apart from each other.

But if it be said: After all, there is no Why; the doctrine of evolution, by doing away with the theory of creation, does away with that of final causes—let us answer, boldly: Not in the least. We might accept all that Mr. Darwin, all that Professor Huxley, has so learnedly and so acutely written on physical science, and yet preserve our natural theology on exactly the same basis as that on which Butler and Paley left it. That we should have to develop it, I do not deny. That we should have to relinquish it, I do.

Let me press this thought earnestly on you. I know that many wiser and better men than I have fears on this point. I cannot share in them.

All, it seems to me, that the new doctrines of Evolution demand is this. We all agree, for the fact is patent, that our own bodies, and indeed the body of every living creature, are evolved from a seemingly simple germ by natural laws, without visible action of any designing will or mind, into the full organisation of a human or other creature. Yet we do not say, on that account: God did not create me; I only grew. We hold in this case to our old idea, and say: If there be evolution, there must be an evolver. Now the new physical theories only ask us, it seems to me, to extend this conception to the whole universe: to believe that not individuals merely, but whole varieties and races, the total organised life on this planet, and it may be the total organisation of the universe, have been evolved just as our bodies are, by natural laws acting through circumstance. This may be true, or may be false. But all its truth can do to the natural theologian will be to make him believe that the Creator bears the same relation to the whole universe as that Creator undeniably bears to every individual human body.

I entreat you to weigh these words, which have not been written in haste; and I entreat you also, if you wish to see how little the new theory, that species may have been gradually created by variation, natural selection, and so forth, interferes with the old theory of design, contrivance, and adaptation, nay, with the fullest admission of benevolent final causes—I entreat you, I say, to study Darwin's "Fertilisation of Orchids"—a book which (whether his main theory be true or not) will still remain a most valuable addition to natural theology.

For suppose, gentlemen, that all the species of Orchids, and not only they, but their congeners—the Gingers, the Arrowroots, the Bananas—are all the descendants of one original form, which was most probably nearly allied to the Snowdrop and the Iris. What then? Would that be one whit more wonderful, more unworthy of the wisdom and power of God, than if they were, as most believe, created each and all at once, with their minute and often imaginary shades of difference? What would the natural theologian have to say, were the first theory true, save that God's works are even more wonderful than he always believed them to be? As for the theory being impossible: we must leave the discussion of that to physical students. It is not for us clergymen to limit the power of God. "Is anything too hard for the Lord?" asked the prophet of old: and we have a right to ask it as long as time shall last. If it be said that natural selection is too simple a cause to produce such fantastic variety: that, again, is a question to be settled exclusively by physical students. All we have to say on the matter is, that we always knew that God works by very simple, or seemingly simple, means; that the whole universe, as far as we could discern it, was one concatenation of the most simple means; that it was wonderful, yea, miraculous in our eyes, that a child should resemble its parents, that the raindrops should make the grass grow, that the grass should become flesh, and the flesh sustenance for the thinking brain of man. Ought God to seem less or more august in our eyes, when we are told that His means are even more simple than we supposed? We held Him to be Almighty and Allwise. Are we to

reverence Him less or more, if we hear that His might is greater, His wisdom deeper, than we ever dreamed? We believed that His care was over all His works; that His Providence watched perpetually over the whole universe. We were taught—some of us at least—by Holy Scripture, to believe that the whole history of the universe was made up of special Providences. If, then, that should be true which Mr. Darwin writes: "It may be metaphorically said that natural selection is daily and hourly scrutinising throughout the world, every variation, even the slightest; rejecting that which is bad, preserving and adding up that which is good, silently and incessantly working whenever and wherever opportunity offers at the improvement of every organic being"—if that, I say, were proven to be true, ought God's care and God's providence to seem less or more magnificent in our eyes? Of old it was said by Him without whom nothing is made: "My Father worketh hitherto, and I work." Shall we quarrel with Science if she should show how those words are true? What, in one word, should we have to say but this?—We knew of old that God was so wise that He could make all things; but behold, He is so much wiser than even that, that He can make all things make themselves.

But it may be said: These notions are contrary to Scripture. I must beg very humbly, but very firmly, to demur to that opinion. Scripture says that God created. But it nowhere defines that term. The means, the How of Creation, is nowhere specified. Scripture, again, says that organised beings were produced each according to their kind. But it nowhere defines that term. What a kind includes,

whether it includes or not the capacity of varying (which is just the question in point), is nowhere specified. And I think it a most important rule in scriptural exegesis, to be most cautious as to limiting the meaning of any term which Scripture itself has not limited, lest we find ourselves putting into the teaching of Scripture our own human theories or prejudices. And consider, Is not man a kind? And has not mankind varied, physically, intellectually, spiritually? Is not the Bible, from beginning to end, a history of the variations of mankind, for worse or for better, from their original type?

Let us rather look with calmness, and even with hope and good will, on these new theories; for, correct or incorrect, they surely mark a tendency toward a more, not a less, scriptural view of nature. Are they not attempts, whether successful or unsuccessful, to escape from that shallow mechanical notion of the universe and its Creator which was too much in vogue in the eighteenth century among divines as well as philosophers; the theory which Goethe (to do him justice), and after him Mr. Thomas Carlyle, have treated with such noble scorn; the theory, I mean, that God has wound up the universe like a clock, and left it to tick by itself till it runs down, never troubling Himself with it, save possibly—for even that was only half believed—by rare miraculous interferences with the laws which He Himself had made? Out of that chilling dream of a dead universe ungoverned by an absent God, the human mind, in Germany especially, tried during the early part of this century to escape by strange roads; roads by which there was no escape, because they were not laid down on the firm ground of scientific

facts. Then, in despair, men turned to the facts which they had neglected, and said: We are weary of philosophy; we will study you, and you alone. As for God, who can find Him? And they have worked at the facts like gallant and honest men; and their work, like all good work, has produced, in the last fifty years, results more enormous than they even dreamed. But what are they finding, more and more, below their facts, below all phenomena which the scalpel and the microscope can show? A something nameless, invisible, imponderable, yet seemingly omnipresent and omnipotent, retreating before them deeper and deeper, the deeper they delve: namely, the life which shapes and makes—that which the old school-men called "forma formativa," which they call vital force and what not—metaphors all, or rather counters to mark an unknown quantity, as if they should call it x or y. One says: It is all vibrations; but his reason, unsatisfied, asks: And what makes the vibrations vibrate? Another: It is all physiological units; but his reason asks: What is the "physis," the nature and "innate tendency" of the units? A third: It may be all caused by infinitely numerous "gemmules;" but his reason asks him: What puts infinite order into these gemmules, instead of infinite anarchy? I mention these theories not to laugh at them. No man has a deeper respect for those who have put them forth. Nor would it interfere with my theological creed, if any or all of them were proven to be true to-morrow. I mention them only to show that beneath all these theories—true or false—still lies the unknown x. Scientific men are becoming more and more aware of it; I had almost said ready to worship it. More and

more the noblest-minded of them are engrossed by the mystery of that unknown and truly miraculous element in Nature, which is always escaping them, though they cannot escape it. How should they escape it? Was it not written of old: "Whither shall I go from Thy presence, or whither shall I flee from Thy spirit?"

Ah that we clergy would summon up courage to tell them that! Courage to tell them—what need not hamper for a moment the freedom of their investigations, what will add to them a sanction, I may say a sanctity—that the unknown x which lies below all phenomena, which is for ever at work on all phenomena, on the whole and on every part of the whole, down to the colouring of every leaf and the curdling of every cell of protoplasm, is none other than that which the old Hebrews called—(by a metaphor, no doubt—for how can man speak of the unseen, save in metaphors drawn from the seen?—but by the only metaphor adequate to express the perpetual and omnipresent miracle)—The Breath of God; The Spirit who is The Lord and Giver of Life.

In the rest, gentlemen, let us think, and let us observe. For if we are ignorant, not merely of the results of experimental science, but of the methods thereof, then we and the men of science shall have no common ground whereon to stretch out kindly hands to each other.

But let us have patience and faith; and not suppose in haste, that when those hands are stretched out it will be needful for us to leave our standing-ground, or to cast ourselves down from the pinnacle of the temple to earn popularity; above all, from earnest

students who are too high-minded to care for popularity themselves.

True, if we have an intelligent belief in those Creeds and those Scriptures which are committed to our keeping, then our philosophy cannot be that which is just now in vogue. But all we have to do, I believe, is to wait. Nominalism, and that "Sensationalism" which has sprung from nominalism, are running fast to seed; Comtism seems to me its supreme effort: after which the whirligig of Time may bring round its revenges; and Realism, and we who own the Realist creeds, may have our turn. Only wait. When a grave, able, and authoritative philosopher explains a mother's love of her newborn babe, as Professor Bain has done, in a really eloquent passage of his book on the "Emotions and the Will" (Second Edition, pp. 78, 79), then the end of that philosophy is very near; and an older, simpler, more human, and, as I hold, more philosophic explanation of that natural phenomenon, and of all others, may get a hearing.

Only wait; and fret not yourselves, else shall you be moved to do evil. Remember the saying of the wise man: "Go not after the world. She turns on her axis; and if thou stand still long enough she will turn round to thee."

THE END.

CHARLES DICKENS AND EVANS, CRYSTAL PALACE PRESS.

00094025

Digitized with financial assistance from the
Government of Maharashtra
on 18 July, 2018